A FURTHER REPORT ON TRYPANOSOMIASIS OF DOMESTIC STOCK IN NORTHERN RHODESIA (NORTH-EASTERN RHODESIA)

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SUMMARY OF CONTENTS.

I. INTRODUCTION

The members of this expedition reached Broken Hill in June, 1907: one of us (A. K.) shortly afterwards proceeding to Fort Jameson and thence to Madona on the river Luapula. The other (R. E. M.) remained at Broken Hill until October, investigating the trypanosome disease in cattle, and then proceeded along the river Kafue and through the corner of the Congo State to Madona, where the first meeting was effected in December. In February a joint tour was made of Lake Bangueolo; A. K. then travelling North via Luena, Kalungwisi and Chienji, and West to Lake Tanganyika and Abercorn. R. E. M. proceeded southwards along the outlet of the Luapula river from Bangueolo and thence North via Mpika, Chinsali and Kasama to effect a second meeting at Abercorn in June, 1908. In August and September the latter made a tour of the Stevenson Road, visiting Kawimbi, Ikomba, Mwenzo, Fife and Chinsali, for a second time, returning to Kambole, where an experimental camp had been built, via Abercorn.

Orders to return to England were received in November, and on the 15th we left Kambole. A. K. proceeded to the coast via Fife, Karonga, Blantyre and down the Shire River; R. E. M. attended the Pan-African Veterinary Conference at Pretoria as delegate of the School, and travelling via Kasama, Mpika, Serenji and Broken Hill reached that place on January 9th, 1909.

Our unavoidable recall to England before the experiments on transmission were fully established is to be regretted, as it was the first occasion since leaving the railway that we were together and were able to remain in one place for more than a few consecutive days, and to attempt anything like continuous experimentation. As a result our observations are necessarily limited and unfinished, and the paramount questions as to whether flies other than tsetse are to be held culpable for the transmission of the trypanosomes we encountered; whether 'game' is the main natural reservoir for these trypanosomes, and whether tsetse are unable to exist without 'game' still await final solution.

We have already reported our observations at Broken Hill: our results on similar conditions in North-Eastern Rhodesia are recorded here together with a summary of our notes on the distribution of

Glossina morsitans and its relation to wild animals. Passing through a country, as we were, it is difficult to place a correct value upon isolated observations; but since our results tend to coincide in many important particulars with those of certain observant residents, and are somewhat opposed to the popularly held beliefs which have been imported from South of the Zambesi, it is deemed advisable to set them forth here for whatever worth they may possess.

The strains of trypanosomes we obtained were carried to Pretoria en route for England, but it was found there that the steamship line by which we were returning refused to permit them to be taken on board. We consider ourselves fortunate that it was to Pretoria they had been brought, for Dr. Theiler has most kindly undertaken to look after them until further arrangements are made.

II. DISTRIBUTION OF STOCK

1. North-Eastern Rhodesia.

Our rapid passage through the country makes it impossible to do more than outline the distribution of domestic stock, and our task is rendered more difficult by the fact that in some districts we did not meet the local official, or were unable to visit his headquarters. We believe, however, that our information is exact, and in most cases one or other of us has visited the European-owned animals. We will discuss the distribution in magisterial divisions.

East Loangwa. In the vicinity of Fort Jameson the Administration has instituted a cattle farm, while settlers and missionaries around this capital all own stock. *Glossina morsitans* is practically limited to the North and North-West, and the natives (Angoni) of the neighbourhood keep cattle. There are a few horses or donkeys or mules in the district which are said to do well. We shall refer later to two outbreaks of trypanosomiasis which occurred in the healthy stock of Fort Jameson as the result of the importation of infected cattle.

The Native Commissioner of Petauki keeps some twenty head of Government animals for milking purposes.

West Loangwa. At Serenji some twenty head are kept by the Official, and the Livingstonia Mission there keep approximately the same number. The central part of this division is free from

Glossina, and we have heard no history of disease. There is only one settler, who has but recently acquired land and hired a few head of cattle from the Administration. We are not acquainted with any native-owned cattle in this division.

Awemba. It will be seen from the map that a large area of this district is tenanted by *Glossina morsitans*, and that only the North and North-West are considered free. The three Government posts of Mpika, Kasama and Luena each keep from twenty to thirty head of cattle for the Official's use, and at Kasama, donkeys and pigs were also seen. At Luena there have been no suspected cases of trypanosomiasis during the past two years, but previously a considerable number of these animals died there from 'fly,' which, it will be seen, encroaches all round. Mpika is also very close, and wandering *Gl. morsitans* have been taken on the station. There are no settlers in this division, but a European trader at Kasama owns a few head for milking. The mission stations of the Pères blancs d'Algiers at Chilabula, Chirui and Chilonga, each keep from thirty to sixty head, and none report the occurrence of disease, though *morsitans* were taken by us within four miles of the last named. It is said by natives that in past years the island of Chirui was joined to the mainland on the East side of Lake Bangueolo, and that tsetse were then existent during the dry season. This island is now somewhat densely populated, and so largely cultivated that nearly all timber has been cut down, and it is no longer connected with the mainland except by hardly fordable swamps of some miles in width. An Awemba chief, Luchembe of the Mpika division, keeps four head of cattle in the centre of *Gl. morsitans.* These animals are said to be the offspring of large herds brought in from raids on the northern tribes fifteen years ago. He has tried to introduce new animals since, but they have invariably died of disease. In the district around Kasama there are forty-five head of native-owned cattle, all of which live towards the border of the Tanganyika division. In Luena there are none. The natives on Lake Bangueolo keep relatively large flocks of sheep, which are said to do well locally; and most villages, even in the tsetse country, keep a few goats.

Mweru and *Luapula.* At Fort Rosebery, Madona, Kalungwisi and Chienji, we saw Government cattle used by the officials for milk. Deaths from 'fly' are said to have taken place at Fort Rosebery, and

the Government animals at Madona, which came from this station, were found to be infected. A trader near Sakontwi has had several deaths, while cattle owned by traders at Madona were suffering from trypanosomiasis. The stock seen at Kalungwisi and Chienji was healthy despite the proximity to both *Gl. morsitans* and *Gl. palpalis*. The mission stations on Lake Bangueolo, at Mbereshi and near the Johnstone Falls, have had no suspicious deaths. Kazembi, an important chief on the Luapula, owns a small herd which grazes on the large grass flats around his village, and Luari owns two or three head. Meri Meri lost a large herd a few years ago, and as noted in our previous report, considers *Tabanus* to have been responsible. Most villagers here keep goats, and a fair number also own sheep.

The distribution of *Gl. morsitans* in this division is not well defined, and we have had it reported to us from several areas where Europeans consider it absent. The importance of this division as a barrier to the spread of human trypanosomiasis makes it desirable that the exact distribution be mapped without delay. It was reported to us by chiefs in the South-East areas, that frequently during the windy season tsetse are carried over towards the South end of Lake Bangueolo from the Luera river, a distance of about twenty miles. At the time of our visit, March 1908, none were seen.

North Loangwa. Government cattle kept for the officials' use were seen at Fife and Chinsali, and those on the Government farm at Ikomba were also examined. A glance at the map will show the range of *Gl. morsitans* over the South of this division; the North, constituting part of the Tanganyika-Nyasa plateau, is free. On this plateau, from lake to lake, cattle are kept by natives, and only occasional sickness is reported. Trypanosomiasis was diagnosed in cattle at Chinsali by Yale Massey in 1905, and deaths have since occurred. At each of our visits (May and August, 1908) we detected cases, both in Government stock and on a settler's place at Scotsdale, three miles distant. Goats and sheep were also infected. As will be noted later, the Chinsali division affords striking evidence regarding the spread of *Gl. morsitans* within recent years.

A Government farm exists at Ikomba which was started in 1900 as a collecting centre for cattle then being purchased in German East Africa, and as a station for transport oxen, at that time in use on the Stevenson Road connecting Lakes Tanganyika

and Nyasa. At the present time it is used as a breeding station, and supplies cattle to the various district officials and replaces their losses in milch cows. Recently, unserviceable cows, males and young stock have been drafted in from these outlying stations, and among some such animals, stated to have come from Chinsali, we found trypanosomes. At the time of our examination of this farm there were 422 head of cattle, of which those that had been bred there were apparently in perfect health. In addition to the settler at Scotsdale, whose cattle, sheep and goats were all infected, there are two others, at Chunga and The Dell, situated within twenty miles of each other, and some twenty to thirty miles north of the present 'fly.' Cattle, some 500 head, at these two farms, looked well; Chunga, by reason of its large open grass flats, being particularly suited to stock. There has been no suspicion of endemic trypanosomiasis at these places, which were stocked originally from the healthy North. At the Livingstonia Mission near Fife some fifty head are kept, and though they were not in the best of condition we were unable to detect trypanosomes among them. On the plateau there are 1,708 head of native-owned cattle.

Tanganyika. The officials at Abercorn and Mporokoso keep cattle for their private use. The latter place was not visited by us, but the information given by the Native Commissioner does not suggest the existence of any acute trypanosomiasis. The disease has never been suspected in Abercorn, and we were unable to find trypanosomes in animals there; but a pig which was sent to us at our camp, fifty miles West, died of this disease soon after its arrival. The history of this animal will be given later, and we merely refer to it since it is possible that its infection may have taken place at Abercorn. Just prior to our visit some five deaths had taken place in a herd of nearly 600 head at a farm twenty-eight miles East of Abercorn, and we were able to see a case said to be similar to those which died. No trypanosomes or other blood parasites were detected, and from the clinical picture presented by this, and the histories furnished, we would support the possibility that a form of vegetable intoxication might be responsible. The existence of this sickness, however, is of interest, since on the route followed by one of us, each cattle-owning village between Kasama and Abercorn complained of disease or deaths. Owing to the absence of *Glossina*

particular attention was paid to these cases, and we purchased a sick animal in order to obtain a post-mortem. The only lesion which could be demonstrated was the presence of *D. hepaticum* in small numbers. Saving for the losses this year, native cattle throughout the division have done well, and tsetse (*Gl. palpalis*) only exist on the shores of Tanganyika and (*Gl. morsitans*) to the West of the division. Cattle are kept at the three stations of the London Missionary Society, Niamkolo, Kambole and Kawimbi. At the first-named there is no history of disease and our examinations were negative. At Kawimbi the cattle appear to have been affected by the same disease which occurred in the native cattle around; at our visit no trypanosomes could be found. Kambole is situated within a few miles of *Gl. morsitans*, though until 1905 cattle are reported to have done exceedingly well. In that year twenty head died, and since then the loss has been from four to six per annum. We found six animals in the herd of sixteen infected; their histories, so far as records are available, and the observations on the trypanosomes will be given later. In the Abercorn district there are approximately 1,200 head of native-owned cattle.

There are consequently between 8,000 and 9,000 head of cattle in Northern Rhodesia, localised, except for special purposes, to the district around Fort Jameson and to the Tanganyika-Nyasa plateau. Sheep are scattered over the territory, but are more extensively bred on the plateau and the district around Bangueolo, and we are informed also in the valley of the Loangwa. Goats are distributed in most villages throughout. Dogs are kept in nearly every village; they are quite neglected, and live principally on offal. Wherever possible, Europeans keep a few, generally of English or colonial breed; and in these the mortality from trypanosomiasis is high, especially as they frequently accompany their masters on tour. Horses are found only at Fort Jameson and Fife; donkeys are met also at certain up-country posts and seem to have a high resistance to the local strains of trypanosomes.

2. Nyasaland.

We were unable to devote any attention to the question in Nyasaland, but the following summary, kindly furnished by the

Governor, Sir Alfred Sharpe, gives the approximate distribution of cattle in that territory. The relation to *Glossina* will be seen on the map:—

CATTLE OWNED IN NYASALAND.

North Nyasa	By Europeans	426	By Natives	13,955
Mombera	,,	146	,,	22,000
West Nyasa	,,	73	,,	2,000
Marimba	,,	205	,,	764
Central Angoniland	,,	1,923	,,	860
South Nyasa	,,	432	,,	63
Upper Shire	,,	873	,,	885
West Shire	,,	197	,,	179
Zomba	,,	1,634	,,	10
Blantyre	,,	3,891	,,	176
Mlanje	,,	557	,,	nil
Ruo	,,	123	,,	150
Lower Shire	,,	173	,,	nil
			Indian	148
		10,653		41,190

The mineral resources of North-Eastern Rhodesia have not yet been developed; as a consequence, no roads exist and the movement of stock is confined. Prior to 1908, Southern Rhodesia, where the cattle had been destroyed by East Coast Fever, afforded a market to the breeders round Fort Jameson; and to speculators who travelled even into German East Africa to trade in cattle with the natives there. These latter drove their purchases by circuitous routes, avoiding tsetse so far as possible, down the Loangwa valley and through Portuguese territory; but the closure of Southern Rhodesia save through the ports of entry at Feira, for driven stock, and at Livingstone, for those sent by rail from North-Western Rhodesia, has practically stopped this movement, and the German frontier has also been closed owing to the rumoured existence of East Coast Fever in that territory.* Traffic in stock between natives is probably rare, and is certainly quite local, and since the Administration have for some years wisely prohibited cattle trading between Europeans and natives, the only movements now taking place are between the few settlers, the stations of each mission society, or due to the

* Government Gazette, North-Eastern Rhodesia, 1907-1908.

drafting of Government stock from the farms to district officials, or to settlers who hire cows for a term of years. Such movements will rarely exceed 100 miles. Transport is entirely by native porters, the few donkeys being used for riding in the district, and are only exceptionally taken any distance. Most of them have come originally from German East Africa.

III. OCCURRENCE OF BITING FLIES

The barrier to the efficient and immediate development of this virgin country is unquestionably the wide distribution of trypanosomiasis and the transmitting flies.

1. *Glossina.* (*a*) *Glossina palpalis* is as yet only known from the river Luapula to the North of 12° South, around Lake Tanganyika and on some tributary rivers. It has not been incriminated for stock in Rhodesia, and cattle at Kalungwisi and Chienji are grazed close to its ranges. The distribution of this fly is given more in detail elsewhere (pp. 281-3).

(*b*) *Glossina morsitans* is found over the greater part of the territory; indeed, if the district of Fort Jameson, the Tanganyika-Nyasa plateau and the neighbourhood of Serenji were excluded, it would be difficult to assert its perpetual absence from any area of fifty miles square. The statement made by Sir Harry Johnston* that this fly is not found in Nyasaland at an altitude of more than 3,000 feet does not obtain in Rhodesia, where the average height above sea level of the heavily infested Chinsali and Mpika districts is more than 4,000 feet, whilst they have been continually taken on the Machinga Hills to the West of the Loangwa, which approach closely to 5,000 feet, and a European crossing the Nyasa-Loangwa watershed East of Chinsali, which is of even greater altitude, states in a letter that he 'found the fly numerous right on the watershed on both sides of the border.' They are equally prevalent in the Loangwa valley (2-3,000 feet), and at less than 1,000 feet on the Shire river.

We were unable to make any personal observations as to the effect of season *per se* on the distribution of this fly; but the reports given us by residents indicate a lack of marked variations. The

* Johnston, Sir H. H., *British Central Africa*, London, 1897.

concomitant factor, wind, unquestionably influences the area of distribution, for during the monsoon the fly apparently disappears almost completely from the exposed places, such as the Loangwa Machingas already mentioned, and is carried over into normally clean country. We may instance in this connection the road which one of us followed at the end of the rainy season (March, 1908) from Kapata at the south end of Lake Bangueolo, via Kisengo and Kalasa to Sakontwi on the Luapula. No *Glossina* were encountered until reaching the river, but all the villagers en route were agreed that in the windy season of each year (June to September) they frequently catch tsetse, and they believe them to have been carried across from the perpetual zones on the Luera river, a distance of about twenty miles. This was supported by an Official; but it is to be admitted that the fact is susceptible of other interpretations.

The chief factor concerned in the distribution, so far as our observations can lead us to a conclusion, is the nature of the country and its vegetation.

The Native Commissioner at Sumbu on Lake Tanganyika has assured us that on more than one occasion he has taken *Glossina morsitans* near to that place, in the middle of a broad grass plain over half a mile in width, and that the fly rise from the isolated and insignificant shrubs which grow on the water-course there. This is the only evidence we have obtained of the occurrence of *morsitans* away from bush country; though the flats may be mentioned which extend from Sakontwi across the extreme corner of the Congo State towards Chitambo. Here, in August, 1907, one of us took this fly from around the tree-studded ant hills which crop up in the bare grass plains at intervals of one hundred to four hundred yards. To a greater degree, are they found in the park-like country which sometimes fringes the true bush country, and connects it with the larger of the open plains. Here the trees attain greater size and substance, but are set at such distances in the grass that the impression recalls a private park in England.

It is in the virgin forest or bush that *Glossina morsitans* takes a permanent abode. This type of vegetation covers the greater part of all watersheds and high-lying country, being broken only by the grassy 'dambos' which serve as drains. These dambos or open grass plains (vlei of the Dutch) commence as narrow strips of thirty

or forty yards in width, accompanying the streams, and like these unite together and sometimes open out as the large grass plains which accompany certain of the rivers. The timber for the most part is small, rarely exceeding thirty feet in height, and relatively open. The shade furnished by these trees is not always intense, but it is sufficient, when in full foliage, to afford comfort after the open. Owing to the almost annual fires, the branches are small and stumpy, and the undergrowth, excepting in a few areas, does not assume any great luxuriance or density and can be traversed with little or no discomfort. In the more densely inhabited regions (three to four inhabitants per square mile is the average) large tracts of this bush have been cut down about four feet from the ground and the land then dug for gardens. After about three years these are deserted, so that the vegetation of considerable areas on the inter-dambo ridges is of a more stunted character, but is apparently equally suited to the fly. The nearest approach to the dense tropical foliage which we met is found in the oases, termed *m'situ*, surrounding some springs; these are small areas rarely exceeding a few acres in extent, where the trees assume forest proportions, and are clothed with rubber vines and other creepers, and are interset with a luxuriant undergrowth; the soil is soft and richly vegetable, and the water is close to the surface. Although on arrival in the territory we were informed that these *m'situs* were tsetse areas par excellence, we have never seen *Gl. morsitans* in any of them, and it is possible that small *Tabanus* and certain *Haematapota*, which are numerous in most, may have been mistaken for *Glossina* by our informants. Regarding the nature of the soil we can say but little; the opinion is held by most Europeans and natives that *Glossina morsitans* avoids clays and swampy surfaces, and favours those of a friable or sandy nature. Our observations tend to bear this out, but the depth of the soil is very variable, being so shallow in many places as to permit of extensive out-crops of the subjacent rock.

There would appear to be no special desire for water on the part of the fly. In most parts of the central region with which we deal, many of the water-courses are dry for two or three months (August to October) at the end of the dry season, and one may have to travel in a direct line for over twenty miles in order to meet a permanent stream, which itself is little more than a trickle; and in instances could

be selected of districts where so far as is known no surface water exists in an area of twenty miles by twenty—400 square miles—and yet *Gl. morsitans* is permanently located there. This is perhaps exceptional, and it is unusual in the part of North-Eastern Rhodesia where we principally travelled, which is well watered by streams that are rarely so much as ten miles apart; but we may instance that to the South-West of N'dola in North-Western Rhodesia.

It is often stated as a fact that this fly will disappear from habitations erected in its haunts. This would appear to be true for North-Eastern Rhodesia, but it would be difficult to say whether it is due to the presence of man or to the inevitable clearing of the bush, with the consequent destruction of its natural haunts, necessitated by the building of many huts and the making of gardens. On many occasions we have taken *Gl. morsitans* within a few minutes of leaving a village, even one long established; and they are frequently located sufficiently close to follow natives daily.

In connection with 'following' flies, which we have watched being carried by natives for over half an hour without attempting to feed, it is an interesting fact, noted alike by the Administrator, Mr. Wallace, and ourselves, that although they may be so numerous as to constitute a perfect plague, most of them will quickly disappear when a camp is made in the midst of their haunts, and also even if the halt is but a temporary rest. On the other hand there are occasions recorded where our first capture on that day has been of flies apparently attracted by our arrival for lunch; these have, however, usually been in small numbers, ten or twelve in half an hour, and not in the swarms so often carried along, where that number could be captured with one sweep of the net, and where the lining of one's helmet and the back of one's neck would be almost hidden, if for a minute the energetic use of a fly switch were discontinued.

Local numerical variations are noticeable, and have frequently been noted by observant residents and by natives, even though the meteorological conditions were similar. On the few occasions when we have travelled more than once over a piece of fly country, it has been rare to see *Gl. morsitans* in the same numbers: on some such roads in the Mpika and Chinsali district they were taken plentifully in April and May, and were not seen in September or December; again at other spots they were taken in these latter months, and were

not seen at our first visit. Our first encounter with *Glossina morsitans* was near Broken Hill in July; not a single specimen could be found at the same time on the following afternoon, though the conditions of sun, wind and temperature were apparently identical.

It is unanimously stated by all who have known this territory for any time, that the area of distribution for *Gl. morsitans* is increasing. A noteworthy case is that of the Chinsali district.

The present Native Commissioner was one of the first Europeans in the country, and reached Chinsali in 1896. As one who had served in Southern Rhodesia previously, he was keenly alive to the importance of tsetse, and paid special attention to its occurrence, since he had been led, on coming into the country via Nyasa and the Tanganyika Plateau, to consider it one suitable for horses. At that time, 1896, from his own observations and from all reports he could receive from natives, *Glossina* was limited in that part of the country now forming his district to the neighbourhood of Itwa and the Chichera River. A map made in 1903, as the result of a special tour, shows the extent of the area then invaded, and to-day, with small exceptions, local and themselves uncertain, the whole district is under the influence of *Glossina morsitans*. The natives of this district are agreed in considering that the fly has enormously increased its ranges within recent years. This is reflected in the figures of native-owned cattle, which have decreased from 149 held by twenty-one owners in 1905, to eighteen owned by four men in 1907, and we were told by this official that in all probability there are now none (May, 1908). We were informed of two specific cases. In 1903 a chief settled in the district bringing with him healthy cattle and sheep. All died within two years, tsetse having encroached upon the land selected. A European on leaving for England in 1907 gave a drove of 13 pigs to a chief living on the fringe of the then fly-free country. Within three months these animals were all dead and the tsetse now surround his village.

There are several areas on the Tanganyika-Nyasa plateau and other supposed fly-free districts which correspond superficially with what we consider suitable *morsitans* country, and there appears no reason why it should not continue to extend. The existence of considerable open grass land in all these districts, however, will so intersect its distribution as to prohibit the infection of more than local strips which are in continuity with the permanently infected zones.

Association with game.

The question of the association of 'game' and *Gl. morsitans* is acutely discussed in Northern Rhodesia, and was ventilated in the *Field* towards the end of 1907. Owing to our temporary acquaintance with the country we are naturally not in a position to make emphatic pronouncements, but we may record here our observations on the diet of this fly. The game of North-Eastern Rhodesia with which we came in contact may be roughly grouped according to the

nature of the country they prefer. Most species at some time come to feed on to the grass dambos, which, as we have already said, are not permanently infested. The larger dambos are selected by some, while others, such as Kudu (*Strepsiceros kudu*), will rarely if ever leave the bush, or only occasionally appear on the fringe of the smallest clearings for a very short time. Rhinoceros (*R. bicornis*) and Buffalo (*Bos caffer*) chose the densest bush obtainable, and are commonly localised to those parts of the country affording this condition. In common with smaller game, they may come into the open in search of water or food, but they are rarely to be seen by sunlight except in the bush. (The local variations in the habit of the *Rhinoceros* which occurs on the plains of East Africa are interesting.) Opposed to these animals are the Sitatunga (*Tragelaphus spekei*) and the Lechwe (*Cobus lichi*), which never approach bush country, but live in the swamps and reeds, and the Sessaby (*Damaliscus lunatus*) and Puku (*Cobus vardoni*), which rarely penetrate into more than park-like country. Intermediate between these groups comes the majority of 'game'—Eland (*Taurotragus oryx*), Sable (*Hippotragus niger*), Roan (*Hippotragus equinus*), Zebra (*Equus burchelli*), Hartebeest (*Bubalis lichtensteinii*), and Waterbuck (*Cobus ellipsirymnus* and *C. defasa*), which spend the heat of the day in the bush, and come to the dambo to feed in the evenings and early mornings; some, as for example Waterbuck, Hartebeest, Roan and Zebra, perhaps favour more the open country, and in this agree with the smaller species, Reedbuck (*Cervicapra arundinum*) and Oribi (*Oribia scoparia*). The Bushbuck (*Tragelaphus scriptus*) is rarely found far from bush of a *m'situ* character, i.e., having water in the vicinity, and the duiker (*Cephalophus grimmi*) and M'pala (*Aepiceros melampus*) will seldom be seen feeding in the open. Pig, the wart-hog (*Phacochoerus aethiopicus*) and the bush variety (*Potomochoerus chaeropotamus*) are also found chiefly to the bush country and the edges of the dambos; and while Elephant may spend some time in and around water in the open, its food, leaves and bark of certain trees, is found in the timbered country and the garden clearings made therein.

We have never seen taken or suspected *Gl. morsitans* on animals grazing in the open, excepting when they were shot almost directly after emerging from the bush.

Reference has already been made to the observation that *Gl. morsitans*, even in its natural haunts, will quickly retreat from a person coming to a halt, although they may have been pestilent immediately prior to this. Our notes would indicate that they may recede from game in the same way, for upon the four occasions on which we came up to resting rhinoceri we could not detect any increase in the number of flies surrounding them—indeed, twice they appeared absent though we had captured them at the same spot on the previous day. The following case is of interest in this connection :—

One of us approached a herd of hartebeest against the wind, being badly annoyed by *morsitans* in so doing, and lay down on an ant-hill within thirty yards of the nearest animals. Four were lying down and four standing up, all apparently asleep, and judging from the 'spoor' they had been there some time. We remained on the ant-hill from 12.35 to 1.10 watching them carefully through prism glasses without being able to ascertain the occurrence of tsetse. Whether from habit or not we cannot say, but it is rare to see any of the tailed antelope keep that organ still for more than a few minutes, and in the present case the standing animals made periodic switches. For the last fifteen minutes of our watch we never saw or felt any tsetse on ourselves, though at least six were present when the ant-hill was reached, and we did not feel any bites. Two of these animals were then shot, but no fly were seen, though the rest of the herd did not at first move off more than 100 yards. On walking away we commenced to collect tsetse again within 200 yards.

Sir Alfred Sharpe and Mr. Harger have referred to districts in Nyasaland where game is plentiful and *morsitans* absent, and conversely, where *morsitans* abound and game excessively scanty. In North-Eastern Rhodesia the same disassociation is met with on localised areas. Speaking broadly, however, the best game country is in the Mpika, Chinsali and Kasama divisions, which for the most part are alternating bush and dambo affording ideal haunts for all varieties; and the concurrent existence of tsetse appears to us to be due to a preference for the same bush country. Certain of the Officials, all keen hunting men and observers, have substantiated this observation, and in reports have quoted instances in their particular districts which go to disprove any intimate connection.

It is well known that Mr. Selous has asserted that a peculiar affinity exists between the buffalo south of the Zambesi and the tsetse which occur there. In Northern Rhodesia there do not appear to be any grounds for this view, and men well versed in the country have denied it. Our own observations were made on the west side of Lake Bangueolo where tsetse are known to be found

periodically. In March, 1908, we followed the fresh spoor of three different herds, and on no occasion did we encounter any *Glossina*.

An answer to this question might be given if the diet of *Glossina* could be satisfactorily determined. It is, we believe, agreed that other blood-sucking Diptera—Culicidae, Tabanidae, and the related genera of the Muscidae, *Stomoxys*, *Haematobia* and *Lyperosia* can exist without blood; but it is commonly held, and Austen has recently emphasised his belief in this view, that *Glossina* demands blood and will not exist on plant juices. This writer bases his argument on the high specialisation of the genus; other writers, notably those from south of the Zambesi, on the rumoured inseparability of fly and 'game.' F. J. Jackson,* Stordy,† and other observers in East Africa, Sir Alfred Sharpe and Harger in Nyasaland and Northern Rhodesia, have failed to notice any intimate connection, and our own work supported this. The extraordinary number of *Gl. morsitans* (almost incredible to one who has not been in their haunts) in many cases where 'game' is exceedingly rare, would appear to preclude the possibility that more than a small percentage could obtain a mammalian blood meal, at what one may suppose to be satisfying intervals. It is recognised that in captivity a tsetse must as a rule be fed *at least* every forty-eight hours; in nature it would often seem impossible for more than one or two per cent. to feed on blood, say, every six or ten days; in some cases, owing to the entire absence of any game indications, it would certainly look dubious if within a dry season the majority could get a blood meal.

Sir Alfred Sharpe in a private letter mentions that he had often been struck by the great preponderance of flies which on crushing apparently contained no blood.

We have never been able to keep captive flies alive for more than ninety-six hours after feeding, but up to that time there was invariable evidence of the meal. Certain variations in the rate of digestion were seen: in a few flies no corpuscles remained after thirty hours, in others they were seen intact after seventy-two. Following the disintegration of corpuscles the gut contents become granular and darker, and pigment grains are seen in the cells lining

*† F. J. Jackson and R. Stordy, vide Austen's *Monograph of tsetse flies*, London, 1903, pp. 295, 291.

the wall. With one or two exceptions this stage was recognisable after eighty-four hours. In these, and in those after ninety-six hours, the gut contents were fluid, only slightly pigmented and largely crystalline, but the cytoplasm of the lining cells is still deeply pigmented. In unfed flies—for present purposes we assume as unfed those showing no pigmentation—the cell contents are dull, finely granular, and free from pigmentation and vacuolisation; in those in which digestion is proceeding the cytoplasm becomes more refractile, less granular, vacuoles of varying sizes make their appearance, and the nucleus is more readily discernible.

It is consequently possible to state with certainty whether a given fly had obtained a meal of blood within four days of examination; it is probable that evidence of the meal remains for at least six days, and it is fair to suppose that a fly showing no signs of blood in its gut has not fed in this manner for five days.

On Lake Tanganyika (*Gl. palpalis*) and at Kambole (*Gl. morsitans*) we dissected nearly 400 freshly-caught flies, of which approximately 66 per cent. showed no signs of blood. Near Mpika 82 out of a total of 112 freshly-caught *Gl. morsitans* (79 per cent.) were free from all traces of haemoglobin, and of the twenty-three which showed such traces five had but recently fed—in three the sucking stomach contained large quantities—most probably from our caravan.

In three *Gl. palpalis* of which we have notes—prior to the first observation it possibly passed unnoticed—the cells lining the intestine from proventriculus to proctodaeum, were in the state we associate with active digestion, that is to say, there was refractility and vacuolisation of the cytoplasm, and the lumen was occupied by a clear fluid. It is impossible to state whether this was due to a pathological condition or to the digestion of a fluid which was not blood.

These observations, though unquestionably limited, would certainly point to *Glossina* as being capable of existence for considerable periods without blood, and possibly to their ability to feed on vegetable juices in its absence. We cannot neglect the additional evidence that 45 per cent. of our *Gl. palpalis* showed an intestinal infection with flagellates, and it is possible that some of

these acquired them through what Minchin* has termed the 'contaminative' method.

As a result we are led to express the opinion that the distribution of *Gl. morsitans* is entirely dependent upon the nature of the country and its flora, the association with the fauna is largely fortuitous, and that a perpetual supply of mammalian blood is not imperative to its at least temporary existence.

Relation to disease

It has become almost an axiom that *Gl. morsitans* indicates trypanosomiasis; much further study is needed to decide this point. Wherever disease exists, whether positively diagnosed as a trypanosome infection or not, and this fly can be caught within five miles or perhaps more, even if it be but a solitary individual, the owner will remain convinced of its causal relationship. There are, however, certain instances which would indicate that this fly may exist within a short distance of cattle without producing any noticeable damage.

In a previous report† we noted an example on the River Kafue, and mentioned two villages (Chinyama and Chiwala) where cattle are, or have been kept, within a mile of permanently infested bush, and which unquestionably at some time have been bitten; indeed *morsitans* has been caught by a European feeding on these animals In North-Eastern Rhodesia we were informed that cattle had been for some time grazed in the Loangwa Valley at a place where we took tsetse, and without any suspicion of infection resulting; and at Mpika and Luena, the natural haunts of the fly are so close that it is difficult to consider that these cattle have never been bitten. The same applies to the native cattle at Luchembe with *Gl. morsitans* all around, and to the Government-owned stock at Kalungwisi (*Gl. palpalis*) and Chienji. Still more striking examples are afforded by those herds which until recently were driven from German East Africa into Southern Rhodesia, approximately 1,000 miles. Of course, every precaution was taken to prevent contact with *Glossina*, and circuitous routes were followed to avoid them; but deaths were

* Minchin. Proc. Roy. Soc. Series B., Vol. 79, No. 528.

† Montgomery, R. E., and Kinghorn, A. A Report on Trypanosomiasis of Domestic Stock in North-Western Rhodesia. Annals Trop. Med. and Parasitology, 1908, II, 2, pp. 97—132.

rare—we have no exact figures—despite a known infection in some of the animals. Mr. Morkel, the manager of the Government Cattle Farm at Ikomba, gave us the following particulars, which afford valuable evidence regarding the effects of *Gl. morsitans* on cattle in one part of this territory.

He travelled with a mob of 800 head of Government cattle from Ikomba to Fort Jameson, starting in November, 1907. The route followed may be seen on the map. *Glossina morsitans* was first encountered on December 25th near Kabomba and it continued practically all the way down the East side of the Loangwa to Chinundu, forty miles from Fort Jameson, which was reached towards the end of March, 1908. At Msikini, where a week was spent, fly was very thick, and at Chipandwi, with fly all round the village, these cattle were quarantined for six weeks. Actually twelve weeks were spent in permanent haunts of *Gl. morsitans*: the cattle marched over 400 miles—roughly 200 of which was in 'fly'—and did so in the middle of the rainy season, with daily storms and several rivers which had to be swum across, and they arrived in Fort Jameson with an actual loss of only eight. Of those which arrived eighteen were believed to be infected (the method of examination adopted in this herd is not known), but we were informed by the Veterinary Officer that after a rest near Fort Jameson the mob was sent on to its destination in Southern Rhodesia and was received there without further loss. It is to be noted that all three dogs which accompanied Mr. Morkel died.

It is assumed as a result of Bruce's work in 1896 that animals ranking as game, constitute the reservoir from which *Glossina* abstract infection, that they are what Minchin* and Woodcock† term 'natural' hosts for the trypanosomes.

What proportion of game is infected cannot yet be estimated; a very small percentage apparently shows peripheral trypanosomes, and it is extremely difficult to carry animals susceptible to inoculation, especially since small laboratory animals would fail to demonstrate at least two organisms pathogenic to domestic stock, *T. vivax* (*T. cazalboui*) and *Tr. nanum*. The number of head showing trypanosomes in the peripheral circulation is certainly small; Bruce‡ failed to demonstrate them in Zululand; Dutton, Todd and Kinghorn§ record three positive findings in twenty-two; and we have found them in only two out of 158 direct examinations. It will be detailed later that inoculations were made from these cases and from a wart-hog and a buffalo shot near our camp, in every case without result. Bruce's inoculations at Ubombo showed approximately

* Minchin. Proc. Roy. Soc. Series B., Vol. 79, No. 528.

† Woodcock. Art. Haemoflagellata in System of Zoology, Vol. 1, Fasc. 1. Edited by Ray Lankester. London, 1909.

‡ Bruce. Further Report on Nagana. London, 1897.

§ Dutton, Todd and Kinghorn. Annals Trop. Med. and Parasit., Vol. I., No. 2.

25 per cent. of the local fauna to be infected; with such a high proportion the *Glossina* should also show a correspondingly high percentage of infectivity, and in Zululand this apparently obtained, for no failures are recorded. That this high ratio of infected tsetse is not universal, is we think shown by the manner in which the cattle already mentioned have been exposed to their attacks for considerable periods without any untoward effects; unless it be assumed that a very latent or chronic infection had resulted.

We have records of feeding fifty-three freshly-caught *Glossina morsitans* on a dog (22), a guinea-pig (25) and a white rat (6), none of which became infected; and no natural infections have been recorded by workers of the Sleeping Sickness Commission,* who used large numbers of freshly-caught *Gl. pallidipes* and *Gl. fusca* at Nairobi. The suggestion was then made that possibly these flies had lost their infectivity during the period elapsing between capture at Kibwezi and feeding at Nairobi, but if Kleine's recent observations† are to be substantiated it must be inferred that they were non-infective at the time of capture.

The Loangwa valley down which Mr. Morkel travelled is one of the best shooting districts in North-Eastern Rhodesia, being very rich in game of all local species; whilst the Kafue river, on which were situated the European farm and Chinyama's village, where no cattle mortality occurs, is one of the richest shooting grounds in North-Western Rhodesia, and, as previously reported, game of various species has been seen grazing with the stock.

Quite dissimilar are the results in the transport cattle taken in 1907 from Broken Hill to Kansanshi, where all the 108 head used on this 250 mile journey died within two months, and all the 42 head sent between Broken Hill and Ndola also succumbed. This result also occurred, on the same Ndola road, to the railway survey party, who lost all their animals in 1905-6 and had to abandon their waggons, and to Mr. George Grey's party proceeding from Kalomo to Kansanshi in 1902.

Reference has been made in our previous report to two experimental animals taken by us between Mwomboshi and Broken Hill which became infected after three *Gl. morsitans* were seen to

* Reports of Sleeping Sickness Commission, No. V, p. 45.

† Kleine. Deut. med. Woch., 1909, pp. 469-470.

feed. In a supplementary note at the end of this report we shall draw attention to the possibility that they derived infection after arrival at our camp.

It is, of course, easy to explain the discrepancies in the evidence quoted as being due to lack of infectivity in the tsetse or the game, or that the trypanosome infection was so mild as to escape clinical detection, but it appears to us that this is a confession of ignorance on the most essential points, upon a knowledge of which improved prophylactic measures might be adopted; and when we add to this the fact that all game experimentally inoculated*—zebra and zebra-hybrids, a springbok, jackals, most monkeys, rats, &c.—became infected, it must be admitted that a thorough re-investigation of the relationship between game, tsetse and disease should be undertaken.

Are other biting flies not implicated in this disease? Tabanidae (*Tabanus* and *Haematapota*) and *Stomoxys* are irregularly distributed over the whole country we travelled; but in much smaller number than *Glossina*. *Chrysops* is uncommon and *Pangonia* was only taken at three places, each roughly twenty miles apart at points of a triangle—Chunga, Dell Farm, and close to Mirwangi Village. We never heard of it elsewhere. *Hippobosca* was not seen by us in Northern-Eastern Rhodesia, but Neave has taken them in the Lovu Valley.

In a previous paper† reference was made to *Tabanus* acting as transmitting agent. A second native has made a similar accusation, asserting that this fly was responsible for many deaths in cattle at Kota-Kota in 1903. Europeans and other natives have never had occasion to incriminate Tabanidae and use the well-worn argument that they exist where there is no disease. Only one exception may be made for the case of a European settler who has blamed *Haematapota* for the death of some donkeys. We have not personally met this settler and have no first-hand data.

The case against *Stomoxys* is different. We have concluded that in an epidemic at Broken Hill this played an active part in extending transmission to those cattle which had not recently at least been in

* Vide Jakimoff. Cent. f. Bakt. 1 Orig., Vol. XXXVII, p. 668. Kanthack, Durham and Blandford. Proc. Roy. Soc., 1898, LXIV, p. 100. Martini. Deut. med. Woch., 1903, pp. 573-575. Grothusen. Arch. f. Schiff- u. Tropenhyg., 1903, VII, p. 387.

† Montgomery and Kinghorn. Annals Trop. Med. and Parasit., Vol. II, No. 2.

'*morsitans* country.' Since then we have learnt of two outbreaks of trypanosomiasis in cattle near Fort Jameson, which, as already noted, is tsetse-free and a cattle raising country. The following is abstracted from the report of Mr. Lane, the Veterinary Officer to the Administration* :—

In March of this year (1908) a few deaths in cattle occurred on a farm twenty-five miles from Fort Jameson, considered at first by the owner to be due to brutality on the part of the herd-boys. Later it was considered to be Biliary fever, and finally the owner attributed the recurrent deaths to liver fluke. In a blood smear, sent in at this time, trypanosomes were found. A visit to the farm disclosed the fact that some Government-owned stock lent to this settler, and which had never before been issued and were then undoubtedly 'clean,' were amongst the infected. This settler admits buying cattle from natives, and I fear that at the time he bought this stock, although showing no signs of disease, they had trypanosomes, and I think a blood-sucking fly had conveyed them to the healthy ones. No 'fly' can be found at this farm, and the owner denies that his animals have ever left. I have little doubt in my own mind that a blood-sucking fly other than the *Glossina morsitans* can convey the disease. It is possible that small numbers of 'fly' may have rapidly crossed the farm, but it is difficult to believe this after hearing the emphatic statements of the owner and his boys who must be cognisant with the tsetse. Up to the present between thirty and forty animals have died.

A second outbreak occurred on a part of the Government Farm thirteen miles from Fort Jameson and the Broken Hill road. Eight head of cattle were sent from Petauke in January, 1908, by the Native Commissioner, who recorded that they all were then in good condition. When they arrived they were naturally, after travelling for over a hundred miles, somewhat poor in condition. These animals were herded with other Government stock at a village on the farm. A month after their arrival they were reported sick, and blood smears showed trypanosomes. Five of these animals have already died. At the beginning of April, I was again called by the foreman of the Government farm, as he reported other animals were sick. These animals were thin and unthrifty in condition, and blood smears showed they were also suffering from trypanosomiasis. The serious side of this outbreak is that some of the animals had not been issued to farmers for a number of years, and others had been on the farm for five or six years. This discovery again points to the fact that a blood-sucking creature other than *Glossina morsitans* can convey the disease in cattle. I must add that every pains have been taken to find out if tsetse fly had visited this district, and from all sources I have got a negative reply.

Mr. Lane concludes by observing that flies 'very similar to, if not the ordinary house-fly,' were present in 'unusually large numbers' and 'were constant suckers of blood of these animals,' and proceeds to discuss the possibilities of mechanical transmission under these conditions.

We have, in North-Eastern Rhodesia, met a European† who has been twenty-four years in tsetse infected districts and who had previously never suspected any fly but these. As a result of his own

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* Kindly forwarded by the Administrator, Fort Jameson.

† Mr. G. Pirie.

observations in January, 1908, he concluded that *Stomoxys* was responsible for the death of two dogs, showing all symptoms of trypanosomiasis, which took place in reported fly-free country.

On a farm—Scotsdale—near Chinsali, we found cattle, sheep and goats naturally infected. One of the infected cattle was a calf four months old. The owner's son said that the cattle habitually grazed on the grass flats just below the farm, but that the calf remained in the homestead or in the gardens around. *Gl. morsitans* does not occur within two miles of the river, across which the calf had certainly never gone. The adult cattle, four, all that remained of twenty-eight, are believed to have been infected on the way to the farm six months before. *Stomoxys* was pestilent in the cattle kraal.

The trypanosome at Broken Hill was *T. dimorphon* and that at Fort Jameson was morphologically of the same type and was pathogenic to dogs.* That at Scotsdale, recalls *T. nanum* in so much that morphologically it shows forms similar to the tadpoles of *T. dimorphon*, and that all inoculations in guinea-pigs and rats have been negative.

While investigating an outbreak of trypanosomiasis in Portuguese East Africa where *Glossina* is said to be unknown, Theiler† has also met with an organism responding to the tadpoles of *T. dimorphon*. Here again other biting flies must be incriminated.

In the face of this evidence it might at first glance appear strange that no outbreaks of trypanosomiasis have occurred in Southern Rhodesia as a result of the importation from the North, of cattle in whose blood trypanosomes have been found on arrival.‡ But due consideration will show that while there is no proof that cases have not occurred there, the chances would be against a free transmission. Owing to the dearth of local stock, due to losses from East Coast Fever, most of the imported animals were intended for slaughter on arrival; further, the quarantine regulations being in force, movement of all stock was prohibited or rigorously controlled. In addition to these factors, which of themselves would inhibit the transmission of

* Private communication of the Veterinary Officer, Fort Jameson.

† Theiler, A. Bull. Soc. Path. Exot., T. II, No. 1.

‡ See Report of Pan-African Veterinary Conference, 1909. Department of Agriculture, Pretoria.

disease, we have no evidence as to the geographical or numerical distribution of *Stomoxys* south of the Zambesi. Again, it is thought by most who have not studied the question that trypanosomiasis must occur in an epidemic form; they do not appreciate the fact that in most countries where the disease exists in the absence of *Glossina*, as for example in India, the greatest mortality occurs as a result of isolated cases and that anything corresponding to an epidemic is relatively rare, and when occurring is due to the circumstances under which the animals were kept. Such isolated cases, where the disease is not suspected, and due to trypanosomes of diverse animal reactions, are most readily overlooked, and the death would probably be ascribed to the commonest complaint. South of the Zambesi the name gall-sickness covers a multitude of diseases.

IV. THE DISEASE IN STOCK

We have met with the disease naturally in cattle, sheep, goats, dogs and a pig; all examinations of donkeys, nine in number, have been negative.

Concerning the susceptibility of *Donkeys*, we would recall that at Broken Hill two were inoculated, and one became infected with *T. dimorphon*. On December 28th, fourteen months after inoculation, he was still at work, and had exchanged hands at an enhanced price owing to his improved condition. The donkey inoculated with *T. vivax* did not show organisms during the period of observation, and five months later he was taken back to Chinsali by his original owner. We examined him there on two occasions with negative results, as also were those made on three other donkeys living close to *Gl. morsitans* and being worked therein, and sleeping in a kraal with trypanosome-infected cattle. The donkeys with which we came in contact apparently possess a high degree of resistance to *T. dimorphon*, *T. vivax* and a trypanosome allied to *T. nanum*. Beyond the mention of donkeys dying after the bites of *Haematapota*, a case already referred to, we have received no information as to their behaviour in other districts to which they may have been taken.

Trypanosomiasis in *Cattle* would appear to vary in intensity very considerably. The severe outbreaks of acute disease at Broken Hill and Fort Jameson contrast markedly with the latent infection at

Chinsali, which has certainly been in existence since 1905, and which normally takes its toll of but two or three per annum.

As will be expected, the symptoms vary with the nature of the infection: from the acute febrile condition of a week or two's duration to the emaciated hairless skeleton, which has presumably taken at least a year to produce. In the absence of any positive diagnosis, recovery may be disputed; but certain owners are emphatic that animals with a history of exposure, and all clinical symptoms of trypanosomiasis, have recovered, and we have examined such without seeing trypanosomes. Neither can the post-mortem appearance be regarded as constant. The enlarged spleen and haemorrhagic glands of the acute case; the oedematous tissues and accumulation of fluid in the body cavities; and the dry, fatless muscles, the pale tissues and organs with slight oedema of the lymphatic glands- the only moisture present—are according to the observation of ourselves and of others, all met with.

Further work on the nature of the trypanosomes encountered in the territory, and their geographical distribution, is required before the questions of insusceptibility, immunity and recovery can be logically discussed.

Goats and *Sheep* are regarded alike by Europeans and natives as immune. On *primâ facie* grounds the disease in them is therefore chronic. We have seen animals three and a half months after the diagnosis of the natural disease in as good condition as at first, and not suspected of sickness by observant owners.

Twenty-three goats and sheep were successfully inoculated with various strains; the only failures, three, being at Broken Hill with *T. vivax* (gland puncture was not resorted to).

Speaking broadly, trypanosomes were generally visible in the peripheral blood, both in naturally and experimentally infected animals, and being apparently in good health, it appears to us that they may act as reservoirs par excellence for the virus, and by trade and movement may become dangerous potential disseminators of the disease.

In *Dogs* the disease, when fatal, appears to be somewhat acute, and accompanied by intermittent fever, progressive debility, opacity of the cornea, and frequently by nervous symptoms. It would seem,

however, that dogs will not infrequently recover from what is clinically a trypanosomiasis.

We have notes given by the owners* of two dogs which travelled from Broken Hill to Abercorn and which were healthy on starting. The only tsetse actually seen were encountered about the middle of April, and were noticed to have settled on these dogs. They arrived in Abercorn the end of April, and a fortnight later, a month after meeting *Gl. morsitans*, both lost flesh, became listless and dull, and had uncertain appetite. This continued for about three weeks, after which they gradually picked up, and at several blood and gland examinations between June and November no trypanosomes were ever seen, and the dogs are both quite healthy.

Two other dogs travelled from Sumbu to Mporokoso, and from four to eight weeks after the journey lost all condition, became veritable skeletons, and were covered with body sores. A third dog which accompanied one of these had to be shot. In one case there was total 'blindness' and opacity of the cornea. They commenced to improve after about two months' sickness but regained their condition very slowly. We examined their blood and glands on several occasions between June and November without finding trypanosomes, though they were still thin.

As indicating the course trypanosomiasis may take in a dog, we may here mention the case of a wire-haired fox terrier which accompanied one of us from Broken Hill and back to the railway nineteen months later.

This dog encountered fly in August, 1907, and was thereafter as much in it as out, and we have on many occasions removed gorged *Gl. morsitans* from him. From December to February he was somewhat less active than usual, and towards the end of that month rapidly lost condition, temperature was elevated and spleen enlarged, but we were unable to demonstrate trypanosomes in the blood. He rapidly recovered, but again fell sick in October, 1908, and trypanosomes were then seen. In November his condition was precarious and a fatal termination almost daily expected. From the night of November 24th he rallied and retained his improvement up to arrival in Pretoria in the middle of January, when, despite his lack of bodily condition from the long journey, he was mentally active. Trypanosomes were not seen in blood and gland examinations between November 13th and January 20th, but death took place from this disease shortly after our departure (Dr. Theiler's letter of April 26th).

We have only seen the disease in one *Pig*; though it has been recorded to us from Chinsali and was then apparently acute. We are unable to trace the infection of this pig, which had been at our camp for three weeks in apparent health. Death took place after a visible sickness of only six hours' duration, with trypanosomes swarming in the blood and post-mortem changes indicating an intensely acute disease. These animals are quite local in distribution and of little economic importance.

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* Messrs. H. C. Marshall and J. Deacon.

V. PROPHYLACTIC MEASURES RECOMMENDED

Prevention.

In a country like Northern Rhodesia we are faced by the interests of two sections of the community—those who wish to breed healthy stock in suitable localities and those who for commercial reasons find it necessary or desirable to keep or expose their animals in localities where the potentialities of the disease—infective tsetse—exist.

For this latter class there is little to be said: the owner is cognisant that all his animals may die, and if he is engaged in hired transport his charges are sufficient to indemnify him. These high rates—we have heard of £60 per ton being paid for transport over 250 miles of road—act most detrimentally to the interests of commerce in a young country, but in the light of our present knowledge there appears no solution. Theoretically the removal of the tsetse, or the source from which they obtain the infection, would bring about the desired result. In practice the former is, as yet, impossible, though according to the theory prevalent amongst those who have been in South Africa, the destruction of the game, which may also be considered the main source from which infection is derived, would be followed by the disappearance of *Glossina*. A serious attempt was recently made near Fort Jameson by men acutely interested in the result, to destroy or drive away the game from an approved area. A successful termination to the experiment would in all likelihood have meant the adoption by the Administration of this means of clearing all areas where cattle movement was desirable, and it may reasonably be supposed, therefore, that every effort was made in order to obtain this substantial assistance. We are informed* that the agitators confessed their inability to make any noticeable impression, and realised the utter impossibility of removing the vast herds of game which tenant the country.

We are more concerned in safeguarding the interests of those fly-free districts where trypanosomiasis is not yet known to be endemic; that is to say the areas of North-Eastern Rhodesia referred to already as Fort Jameson, the Tanganyika-Nyasa Plateau and Serenji; the areas south of the River Kafue, the Barotse and Masha-

* Private communication from Fort Jameson.

kalumbue countries, and other localised parts in North-Western Rhodesia, together with the healthy parts of British South Africa.

We fully realise the issue at stake, its predominant importance, and the difficulties to be contended against, especially the local or individual considerations which must be respected. In brief, the suggestions offered are set out below, and, since the native does but little cattle trading except with Europeans, and this is now prohibited, they are drawn up as regards bona-fide settlers and stock owners.

1. The first essential is to obtain maps with the distribution of all species of *Glossina* and the occurrence of the disease, made to the satisfaction of the local officials in concert with representatives of the local stock owners. A central committee in each territory, which should include the Chief Veterinary Officer and delegates of the stock-owning community, would proceed to divide the territory into the two heads ' Infective 'and ' Clean.'

Under Infective would be marked all areas permanently inhabited by *Glossina* of any species and a zone of not less than five miles surrounding, and all places without, if any, where the disease may be considered endemic.

Clean would, in general, be ' fly free ' areas.

2. All equines and bovines resident within the infective areas, as at outlying Government posts, farms, mines and missions, should be branded in a distinctive manner, and a register of all such animals, containing a full description and all marks of identification, should be kept, and all equines and bovines entering an infective area from without should be similarly branded and registered.

3. As soon as possible an inspection should be made of all stock domiciled within the ' clean ' areas and a certificate issued by the Chief Veterinary Officer to stock owners who have branded or otherwise identified their animals in a register to the satisfaction of the Inspecting Officer, and whose animals are free from this disease. Should a case of trypanosomiasis be detected, that area should be regarded as temporarily infective and should be placed in quarantine. By stock is here meant all equines, bovines, sheep, goats, swine and dogs, and should also include any wild mammal kept in captivity which at the discretion of the Veterinary Officer might be held to constitute a danger.

4. No movement of any animal should be permitted from an infective to a clean area save with the sanction of a Veterinary Officer, and on no account should any such animal be allowed to approach within 400 yards of clean stock.

5. All premises, herds or flocks of a clean area in which a case of trypanosomiasis has been found, and all stock entering from an infective area should be placed in quarantine, and not allowed to come within 400 yards of any other stock.

6. Quarantine should be maintained for at least three months after entry, or, in 'contact stock,' after the diagnosis of the last infected case. All animals therein should be subjected to repeated blood examinations, gland puncture or sub-inoculation, and at the expiration of that term they should be carefully registered and liberated on a veterinary certificate.

7. Every case of trypanosomiasis in a clean area should be immediately destroyed; or in certain approved instances placed in a special segregation camp situated at least 400 yards from all other stock.

8. These suggestions should be so amended as to permit of respect being paid to the legitimate requirements of localities or individuals; as, for example, in the case of dogs, which might, after inspection and registration, be permitted to remain with, and at the responsibility of their owners; and certain latitude might be permitted in the case of cattle, sheep and goats intended for slaughter.

The adoption of these suggestions would, we think, effectually prevent the introduction of trypanosomiasis into the districts at present believed to be free from it; and if the definitions of infective and clean areas were made in consultation with the Governments of South African Colonies and the clean areas proved to their satisfaction to be free from disease, there could be no objection to a proposal that legitimate trade, subject only to the ordinary restrictions, should not proceed uninterruptedly with the clean areas South of the Zambesi. At present, with the existing conditions largely unknown, Northern Rhodesia as a whole is regarded with a certain degree of suspicion, a punishment which reacts with disproportionate severity upon the large cattle breeders established in healthy districts.

A careful examination of these suggestions will show they do no more than protect the healthy, and will in no way interfere with

existing trade, but are designed rather with the object of organising this, to the best individual and collective advantage.

Besides legislative interference, however, it is to be urged that stock owners should be made acquainted with the full etiology of trypanosomiasis as at present known, and every effort made to discourage the views previously held that the tsetse alone can give infection and that goats and sheep are not attacked. These animals, and donkeys, when indiscriminately moved, may, owing to their apparent health be of greater danger to cattle; and legislation should carefully deal with them, for their identity and registration will be difficult.

VI. THE TRYPANOSOMES ENCOUNTERED

(*a*) In Naturally Infected Ruminants

1. '*Scotsdale.*'

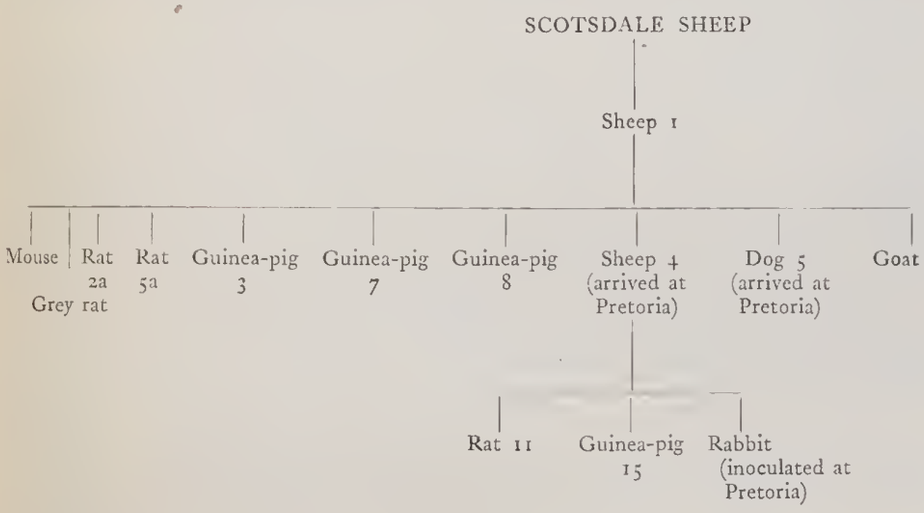
Origin: At our first examinations, May, 1908, of the stock on a farm known as Scotsdale, some three miles from Chinsali, we found four cattle out of five, four sheep in eleven, and one goat in four to show trypanosomes. These cattle had been brought from the Loangwa valley, and it is possible they were infected on the road, for *Gl. morsitans* exists plentifully on that side of the farm. On the other hand, a calf born on the place and not exposed to this fly was infected—a case which suggests the operation of a local genus such as *Stomoxys*, which was very prevalent in the kraal occupied by all the stock. Owing to the owner's absence we were unable to learn much regarding the natural disease in these animals, but it would appear, from what was adduced, that it passes unnoticed in sheep and goats, and lasts at least six months in most bovines. On our second visit, four months later (August-September), we found that only one cow had died in the interim; the other bovines, excepting the calf, did not appear much thinner; the sheep and goats still retained their normal condition.

In May, two rats were inoculated intraperitoneally with 0·5 c.cm. and 1·0 c.cm., respectively, of citrated blood from two of these cows. They did not become infected. On our subsequent visit two rats and two guinea-pigs were given intraperitoneal injections of from 3·0 to 10·0 c.cm. of blood containing trypanosomes (in one

case, two to a field) from three bovines, without result. The owner had very kindly written, giving us permission to take away an infected sheep or goat that the strain might be carried to our camp at Kambole; and a sheep which showed trypanosomes at both visits was selected. We take this opportunity of thanking Mr. Yule for his consideration, without which even the little possible could not have been done.

This sheep was carried in an improvised hammock for ten days, when it was found to have lost its condition and become very weak. On the twelfth it was *in extremis* and was destroyed (September 12th), and 5·0 c.cm. of blood containing trypanosomes one to a field was injected into a Sheep No. 1, which had been purchased in a healthy village and been examined by blood and gland puncture on three occasions with negative results. This sheep, which became infected about the eighth day, reached Kambole on September 21st, and served as the source of the strain.

The following is the genealogy of this strain:—



Experimental

The inoculations here described are those carried out with the original Scotsdale sheep, or its passage through Sheep 1.

Rats.—Two white rats received, the one, No. 2a, 6·0 c.cm. (24.9.08), the other, No. 5a, 5·0 c.cm. (22.10.08) intraperitoneally, of blood containing numerous trypanosomes from Sheep 1. One white rat, No. 11, received 10·0 c.cm. (25.10.08) intraperitoneally from Sheep 4 (inoculated from Sheep 1) trypanosomes one to a field. None of these rats became infected.

Guinea-pigs.—Three guinea-pigs were inoculated intraperitoneally from Sheep 1; No. 3, 6·0 c.cm; No. 7, 30·0 c.cm; No. 8, 20·0 c.cm; and one, No. 15, with 15·0 c.cm. from Sheep 4. None of these became infected.

A Wild Mouse (Sp. ?) received 0·4 c.cm. subcutaneously, and a Grey Rat 3·0 c.cm. intraperitoneally from Sheep 1. The mouse escaped on the 18th day, but had not up till then shown trypanosomes. The rat was under observation for two months and trypanosomes were never seen.

Rabbit.—We were unable to utilise rabbits in Rhodesia, but on arrival in Pretoria a rabbit was inoculated intraperitoneally with 5·0 c.cm. citrated blood of Sheep 4. Trypanosomes appeared on the seventh day. Further observations are necessary to determine the constancy of this reaction in rabbits, but there is no reason to consider that any contamination of this strain had been effected during the journey.

Dog 5.—An adult 'Kaffir' dog was inoculated intraperitoneally on October 22nd, 1908, with 10·0 c.cm. citrated blood of Sheep 1. The temperature became irregular from the eighth day and reached 103·6 on the evening of the thirteenth. During the daily examinations to November 15th no trypanosomes were ever seen either in the peripheral blood or on gland puncture, and the dog remained healthy in appearance. On November 27th one trypanosome was seen in a ¾-inch cover-glass preparation. From that date to January 20th, at Pretoria, they were not again seen.

Sheep.—A naturally infected sheep was presented to the Expedition by Mr. J. B. Yule, of Scotsdale, and constituted the origin of this strain. It was in fair condition at the time of leaving Scotsdale, but rapidly became debilitated with travelling, though carried in a hammock, and was destroyed, when *in extremis*, on September 12th.

Sheep 1.—September 12th, 1908, inoculated subcutaneously with 5·0 c.cm. blood direct from the original animal. Organisms appeared about the eighth day. It was carefully carried to our camp at Kambole and on arrival there, September 22nd, showed trypanosomes. The temperature was elevated and irregular, and did not show the striking picture manifested by a chart of the Broken Hill *T. dimorphon*. Organisms were present daily up to September 30th and were then absent for ten consecutive days, reappearing on October 11th. From October 1st the temperature assumed a much more irregular type which persisted to October 23rd when the animal died of septic pleuro-pneumonia.

Sheep 4.—October 10th, 1908. Inoculated intraperitoneally with 30·0 c.cm. citrated blood of Sheep 1. This large dose was given as trypanosomes had not been seen for ten days.

Organisms appeared on the sixth day and have been almost constantly present since, though always in small numbers, it being rare to see so many as one to the field, more commonly one to five or ten fields being noted.

The temperature showed little abnormality, and no paroxysmal tendency.

This sheep ('long-eared') was carried to Pretoria where it is under the care of Dr. Theiler who, under date of April 26th, writes that it is still alive.

Goat 2.—Inoculated subcutaneously with 5·0 c.cm. blood of Sheep 1, October 22nd. The temperature suddenly rose to 105·7° the evening of the tenth day, and trypanosomes were present the following morning, and were seen daily, with two exceptions, during the twelve days this animal was observed. The temperature tended to assume the type noted with Broken Hill *dimorphon*, being elevated to 106° and 107° about every second day. It was destroyed, having shown itself susceptible on the twenty-second day.

The following inoculations were made from other animals at 'Scotsdale'; it is believed that the trypanosome is the same.

From Cow A.

May, 1908: White rat 0·5 c.cm. intraperitoneally.
August, 1908: White rat 3·0 c.cm., Guinea-pig 5·0 c.cm., intraperitoneally.
No infection resulted.

From Cow B.

May, 1908: White rat 1·0 c.cm. intraperitoneally.
August, 1908: White rat 5·0 c.cm. intraperitoneally.
No infection resulted.

From Calf.

August, 1908: Guinea-pig 10·0 c.cm. intraperitoneally.
No infection resulted.

At our first visit to Chinsali, the position of which with regard to *Gl. morsitans* has already been discussed, two cows in a herd of nine adults were found infected. No reliable history regarding these animals could be obtained owing to a change of Native Commissioner and the fact that no individual records are kept; but it is possible that these animals came from Mirongo three months prior to our visit. *Gl. morsitans* exists on that road.

These same animals were again seen at Ikomba Government Farm in August and September and were still infected. The drafting of these cases to a healthy area is a source of danger which could be avoided; it shows also the desirability of branding and identifying all stock in these areas, since it was only by our own notes and enquiries that they were proved to be the same cattle, and not cases of trypanosomiasis occurring spontaneously on this Farm.

The morphology of this trypanosome is identical with that at Scotsdale, and we consider it probable that they are the same species.

The following inoculations were made at Chinsali:—

Cow A.

May, 1908: White rat 0·5 c.cm. intraperitoneally, Guinea-pig 2·0 c.cm. intraperitoneally.

Cow C.

August, 1908: White rat 2·0 c.cm. intraperitoneally, Guinea-pig 6·0 c.cm. intraperitoneally.

In no case did infection result.

At Kasama, in May, we found a sheep, which had arrived from Lake Bangueolo four days previously, showing trypanosomes which are morphologically identical with those occurring in the Scotsdale

sheep and goat. One inoculation was made, 0·5 c.cm. intraperitoneally into a white rat, without result.

Morphology of the 'Scotsdale' Trypanosome

In slides made from the infected animals at Scotsdale, it was seen that the trypanosomes in the sheep and goat differed morphologically from those in the cattle, and the occurrence of a dual infection was suspected. From the observations on Sheep I, however, it was shown that there are variations of the same parasite. We may commence with a description of the forms seen in this animal.

A. '*Long form.*' In fresh preparations the parasite is relatively active, crossing the field with a steady undulating movement of the flagellar extremity, a passage easily followed and one creating but little commotion among the corpuscles. When arrested the movements become more vibratory. On no occasion was the activity manifested by *T. vivax* exhibited.

In stained preparations We employed Giemsa's solution during the earlier part of our work, but later used Leishman's stain freshly prepared in methyl alcohol from the powder made by Grübler. This did not appear to deteriorate as did Giemsa's solution, although this had been taken out in small 10·0 c.cm. bottles.

This trypanosome measured from 20·5 to 25·6 μ (average 24·74 μ) in total length, and 2 to 3 μ (average 2·7 μ) in breadth. A free flagellum was present, accounting for 5·5 to 8·5 μ (average 6·3 μ) of the total. The mean of a series of measurements is as follows:—

Extremity to Blepharoplast	Blepharoplast to Nucleus	Nucleus	Nucleus to body extremity	Free Flagellum
0·85	6·39	3·2	8·0	6·3

The posterior extremity is rounded or bluntly conical; cytoplasm stained a deep pink and is free from granules or vacuoles. Blepharoplast round and prominent, situated about its own length from the extremity. Nucleus compact, but not deeply stained, oval in shape, measuring approximately 3 × 1·8 μ, and situated about the centre of the body. The undulating membrane is poorly developed, existing as a narrow band, or, less commonly, showing

one or two small folds. The flagellar rim stains deeply; arising from an achromatic area, it is continued as a free portion of up to 8·5 μ in length.

B. '*Short forms.*' In fresh preparations this trypanosome is slightly more active than the tadpole of *T. dimorphon*; the difference, however, is only appreciable on close comparison.

Stained, it is indistinguishable from the tadpole forms of *T. dimorphon*. In length it measures from 10·75 to 14·8 μ (average 13·56 μ), and is from 1·25 to 1·65 μ in width. The mean of a series of measurements gives:—

Extremity to Nucleus	Nucleus	Nucleus to flagellar extremity
3·94	2·6	7·12

The cytoplasm stains somewhat deeply and is free from granules; vacuoles situated close to the blepharoplast were seen in two or three specimens. The blepharoplast is small and placed close to the extremity; the nucleus, relatively large, stains deeply and measures from 2·25 to 3 μ in length and from 1 to 1·5 μ in breadth. In most individuals it is oval or drawn out, but in some it was almost rounded. There is practically no undulating membrane; and these forms are devoid of any free flagellum.

The original sheep of this strain when examined in May, and from August up to its death, showed only the long forms. This form re-appeared in Sheep 1 on inoculation, and remained present until September 30th. Between that date and October 10th no trypanosomes were seen in this animal, but on their re-appearance they were practically all of the short tadpole variety. A careful examination of some of our films shows that in Sheep 1 prior to September 30th one or two tadpoles were present, and a long form has been seen since October 10th. In the sub-inoculation made on what proved to be the last day of the period of absence, the tadpole form re-appeared in Sheep 4, and is the form which was present at the last examination in Pretoria, January 20th.

The other sheep and the goat at Scotsdale, and the sheep at Kasama, showed the long form; but an occasional tadpole was seen; in the cattle at Scotsdale and Chinsali none but tadpoles were found in the peripheral blood.

In Goat 2 and the Pretoria rabbit, tadpoles appeared; and the one trypanosome seen in a fresh preparation from Dog 5 was also of this variety.

Diagnosis

It may be questioned if these two forms are really of the same species. We think they are. Whether inoculations were made with tadpole or long, the results in white rats and guinea-pigs were invariably negative. Both forms existed at a farm where all animals were herded together and where an autochthonous case is believed to have occurred;* and examples of both varieties have been seen in films where one or other preponderated. Further, the history of Sheep 1, which we consider was 'clean' at the time of inoculation, indicates a change in morphology rather than a re-infection at our camp, situated nearly 200 miles from the only locality in which a trypanosome non-pathogenic to small animals was seen. That the tadpole was not *T. dimorphon* is, we think, clearly indicated by the failure to infect rats and guinea-pigs with doses of 10 to 30 c.cm. of blood showing trypanosomes.

In morphological characters the 'long' form is almost indistinguishable from *T. vivax* and *T. cazalboui*; it is certainly less actively motile than the Broken Hill *T. vivax*, but no reliance should be placed on such a variable quality. No reference has been made by Ziemann, Laveran or other writer on this species, to the occurrence of any form recalling the tadpole *dimorphon* in naturally infected or sub-inoculated animals; Laveran has had a unique opportunity of observing such forms did they occur in *T. cazalboui*.

The tadpole forms correspond by morphology and animal reaction to the original descriptions of *T. nanum* given by Laveran† and Balfour,‡ and to that of Wenyon,§ who appears to have regained this species in the Anglo-Egyptian Soudan. The last named writer has also described 'long' forms of 'about 20 μ, 5 μ of which are taken up by the free flagellum,' and in fig. 39 shows forms which by their rounded posterior extremity, situation of the blepharoplast,

* Vide page 333.

† Laveran. *C. R. Soc. Biol.*, 1905, Vol. LVII, pp. 292-294.

‡ Balfour. Second Report of the Wellcome Laboratory, 1906, p. 122.

§ Wenyon. Third Report of the Wellcome Laboratory, 1908, p. 137.

and development of the undulating membrane, recall the 'long' form which we figure in plate. We assume from Wenyon's remarks* that both 'short' and 'long' occurred simultaneously, but it is to be regretted that a more detailed account of these experiments and observations was not published. The possibility of a mixed infection in a given animal is manifest in a trypanosome-infected continent like Africa, from which already *T. gambiense*, *T. evansi*, *T. brucei*, *T. equiperdum*, *T. dimorphon*, *T. vivax*, *T. nanum*, *T. congolense*, *T. cazalboui*, *T. pecaudi*, and *T sudanense* have been announced in domestic animals. Still greater is the possibility of more than one species occurring in any given herd; one has but to review the recent publications from French West Africa to appreciate this fact, and our own observations at Broken Hill and at Kambole teach the necessity of keeping distinct genealogical records. It is easy to assume the identity of the trypanosomes in the case of two animals infected with such morphologically similar trypanosomes as tadpole *T. dimorphon* (*sensu*, Dutton and Todd, 1903), and tadpole *T. nanum* (*sensu*, Laveran and Balfour, 1905). Rats are inoculated with the latter with negative results; from the former an inoculated sheep is used for all subsequent work, the results of which are directly opposed to those previously obtained, and the inevitable sequel is that considerable confusion occurs in the literature.

The precision and lack of confusion regarding trypanosomes which have been studied in Europe—trypanosomes taken there in individual animals—or in Africa where morphology and diagnosis has been effected by the animal reactions of the strain from one animal alone (e.g., the original *T. nanum* and some trypanosomes of the Sleeping Sickness Commission in Uganda), contrast forcibly with the chaotic state of the literature concerning other African trypanosomes to-day.

T. nanum was constituted on the morphological observations of Laveran and the animal reactions noted by Balfour. To be identified with this species, a trypanosome must conform to these original descriptions whatever additional features are brought to light by subsequent investigations.

* We have had the privilege of examining some of Dr. Wenyon's specimens. The long form which we describe is morphologically different.

Rigorous rules cannot be laid down for the nomenclature of trypanosomes; but, in general, it may be admitted that *T. nanum* is short and tadpole-like, from 10 to 14 μ, and is *relatively* innocuous to laboratory animals. A strain virulent to all would cease to be *T. nanum*. It is therefore to be hoped that more details of the strain with which Balfour infected gerbils, and Wenyon infected dogs from which a gerbil was successfully inoculated, will be published. They were derived from different sources, a mule at Wau and a heifer at Sobat; but we do not know whether it is from the *same* animals that the fourteen out of fifteen rats were inoculated without result.*

We write with the sole idea of analysing the present references to *T. nanum*, and to point out that it is with the original descriptions of this species that we associate the 'Scotsdale' trypanosome, and that we have noted the same morphological variations as has Wenyon. It will, however, be necessary to verify the reaction in the rabbit at Pretoria as being due to the uncontaminated original strain, and to show that it is there still *relatively* innocuous to laboratory animals before accepting that the strain Sheep 4 is that with which the above experiments were carried out.

2. *Kambole Strains*

Kambole is the name of a Mission Station situated on the high land above Lake Tanganyika and the Lovu River, and some fifty miles West of Abercorn. It was selected as suitable locality for an experimental camp owing to the fact that both *Gl. palpalis* and *Gl. morsitans* could be caught within a few miles. One of us arrived there early in August, the other during the third week in September. Until our sudden departure for Europe on November 15th, we had an opportunity of studying the trypanosomes in the mission cattle and of comparing them with the other strains we had accumulated. Only elementary diagnostic work was possible, owing to the great scarcity of small animals: our object was rather to maintain the strains so that they could be brought home, and at the same time arrive at some idea as to the nature of the trypanosomes encountered

* Dr. Wenyon has kindly given us some unpublished particulars of his work on this trypanosome. They indicate forcibly that while rats are insusceptible (he used a wild species), *young* dogs and gerbils may readily take infection. In some cases these animals were inoculated from the same infected beast.

and their 'animal reactions,' that they might be of service in the transmission experiments we contemplated.

The history of the cattle on this station is of interest. Between 1896, when the Mission was established, and 1905, cattle, sheep, goats and pigs are reported to have done exceedingly well. In 1905 the herd of nearly 60 head was divided, half going to the Luapula River, where they have since done well, the others remaining at Kambole. The owner of the latter half was away in May and June of this year, and six weeks after his return (i.e. August) the cattle commenced to die, and twenty were lost before Christmas. In 1906 four deaths are remembered, in 1907 six, and up to our visit in 1908 seven had died. Several additions to the herd had been made by movements from other stations of the same Missionary Society, e.g., Niamkolo and Kawimbi, bringing the number of adults present at the time of examination up to 15. Of these six were infected. The herdman who brought the original stock from the North end of Lake Nyasa in 1896 is still at Kambole, and he is unable to offer any explanation as to why cattle did so well and were free from disease up to 1905, and have since died in such numbers. He avers, and the local natives support him, that these cattle have always grazed on the same areas, and that 'tushembe' was always to be found if the animals wandered far. Unfortunately the name 'tushembe' is applied here to all biting flies, and the natives do not recognise or distinguish *Glossina*, for which this vernacular word is usually restricted. It is possible that an extension of tsetse may have occurred without notice. At the present time *Gl. morsitans* may be taken within three or four miles to the West, and wandering flies were captured on the Mission during our stay near there.

Two of the infected cattle—'Balungu' and 'Ninamwenda'—were selected for the isolation of the strains, since the morphological appearances of their trypanosomes showed some points of difference.

A. *'Balungu' strain.*

This six-year-old cow was born at Kambole. She showed the hide-bound dejected appearance of a chronic case, with slightly anaemic membranes and enlarged superficial lymphatic glands, but no oedemata. She was examined on five occasions, trypanosomes being present in the peripheral blood on each, and she was destroyed

in extremis on November 7th, 1908, having been sick for approximately nine months.

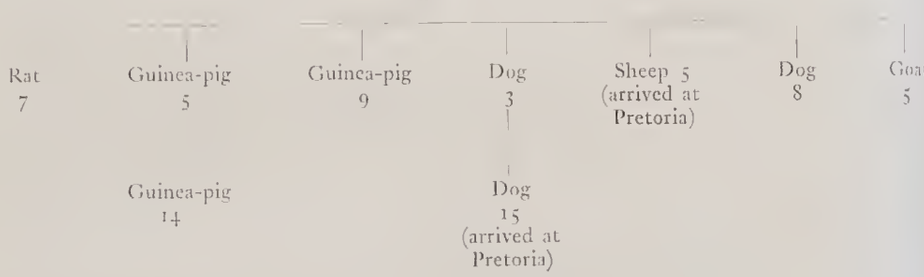
Autopsy. All subcutaneous tissues were pale and somewhat dropsical. The superficial glands were considerably enlarged and oedematous. The abdominal cavity contained a slight excess of deep citron-coloured fluid. The peritoneal covering of the rumen, reticulum, spleen and areas of the intestine was studded with petechiae, in parts congregated into patches two inches in diameter. The mesentery was infiltrated with a gelatinous material. The liver was slightly congested; the gall-bladder distended and contained over 900 c.cm. of reddish watery bile. The spleen was somewhat enlarged, the surface studded with petechiae, the pulp dark and friable, and Malpighian bodies prominent.

There was no excess of fluid in the thoracic cavity or pericardial sac. Slight lobar congestion and emphysema of both lungs. The heart, pale and very flabby, showed fatty degeneration; the base was surrounded by a quantity of gelatinous material replacing all fat.

The mesenteric and mediastinal lymphatic glands were enlarged and oedematous and some of them were congested.

The following is the genealogical record of this strain:—

BALUNGU



Experimental infection

Rat 7.—Considering it possible we might be dealing with 'Scotsdale' Strain, 10 c.cm. blood of naturally infected cow was inoculated intraperitoneally into this animal, on October 23rd. Negative on the 29th; trypanosomes were seen on November 1st and remained present until death on November 10th—17 days.

Guinea-pig 5.—October 8th, 1908. Inoculated intraperitoneally with 5 c.cm. blood of naturally infected cow. Almost daily examination up to November 10th failed to reveal any infection, so the animal was re-inoculated on this date with about 2·0 c.cm. heart blood of Rat 7 just dead. Trypanosomes were seen on November 23rd, the first examination since November 13th, and were present at succeeding observations till death on December 12th.

Guinea-pig 9.—Owing to the initial failure to obtain infection in Guinea-pig 5, this animal received 10·0 c.cm. intraperitoneally on October 23rd. Trypanosomes first seen November 1st; they were not seen on the 5th or 7th, but thereafter were constantly present—but *always in small numbers*, 2 in ¼ of a cover (¾ inch) being the maximum noted until a week prior to death, which took place on December 4th (41 days), when they became more numerous, up to two per field.

Guinea-pig 14.—December 12th. Inoculated intraperitoneally with 0·5 c.cm. heart blood of Guinea-pig 5. Trypanosomes were seen one to a field on December 18th, and the animal died on December 22nd. Death was undoubtedly largely accelerated by, if not due to a vegetable poisoning which accounted for the loss of three other guinea-pigs the following day.

Dog 3.—October 8th, 1908. Inoculated intraperitoneally with 5·0 c.cm. blood of Balungu. The temperature rose to 102° on the fourth day, and continued slightly elevated between 102° and 103°, with few exceptions, to death. Trypanosomes appeared 1 in ¼ cover on the eighth day, and remained present in small numbers, 1 in 10 fields being the maximum, up to November 15th when they were about 12 to a field. Death took place on November 21st—44th day after inoculation.

Dog 8.—October 31st. Inoculated subcutaneously with 1·0 c.cm. blood of Balungu. Temperature rose almost immediately to 102° and continued irregular so long as it was taken. Trypanosomes were never seen in the blood, but gland puncture on the 10th and 19th day after inoculation showed them to be present. Death took place on December 4th (35 days) from pneumonia. Trypanosomes could not be demonstrated, and the spleen was normal.

Dog 15.—November 25th. Inoculated subcutaneously with 3·0 c.cm. heart blood of Dog 3 just dead. Trypanosomes were never seen in the blood or gland juice of this animal up to his arrival in Pretoria.

Sheep 5.—October 23rd, 1908. Inoculated intraperitoneally with 6·0 c.cm. blood of Balungu. Trypanosomes were seen 1 in ½ cover on the sixth day, and were subsequently found in small numbers (1 in 1 on one occasion only). The temperature showing indications of the Broken Hill *dimorphon* type, but less marked. This animal was taken to Pretoria, and was still living on January 23rd. Dr. Theiler informs us on April 26th, 1909, that this sheep has since died.

Goat 5.—October 31st, 1908. Inoculated subcutaneously with 1·0 c.cm. blood of Balungu. The temperature rose steadily and reached 106·4° on the evening of the eighth day, and continued irregular. Trypanosomes were not seen in the peripheral blood until the 14th day (1 in ¼ cover); they had, however, been seen in the glands since the ninth day. The animal was destroyed when the infection was realised.

Morphology of 'Balungu' trypanosome.

The trypanosomes seen in the original cow and the sub-inoculated animals, rat, guinea-pigs, dogs, sheep and goat, are of the same appearance. They correspond closely with the tadpole form of *T. dimorphon* (Plate IV, fig. 3).

In fresh preparations the movements are localised to the field, and are not very active.

In stained preparations the length varies from 10·2 to 16·3 μ (average 13 μ), the larger being divisional form, and the breadth from 1·0 to 2·2 μ (average 1·5). The following is the mean of a series of measurements:—

Extremity to Nucleus	Nucleus	Nucleus to flagellar extremity
4·93	2·07	6·08

The blepharoplast is not quite terminal (0·5 to 1·0 μ from the end); the nucleus is oval or compressed, and is placed rather towards the posterior extremity. The undulating membrane is rudimentary, and there is no appreciable free flagellum. The posterior extremity is rounded or bluntly conical. The cytoplasm is commonly homogeneous, but in some slides a considerable proportion show a clear area (? vacuole) near the blepharoplast, whilst many exhibit a few fine chromatic granules between the blepharoplast and the nucleus. The greatest width is posterior to the nucleus.

Diagnosis

From its morphology it is quite evident that this trypanosome is not related to the *evansi* group; and by its pathogenicity to small animals it is separable from the *vivax* group, and consequently from *T. nanum*, though on morphological grounds alone it would be impossible to distinguish it from the tadpole forms of this latter.

According to our rough grouping* it would fall under the head of *dimorphon*, here containing the three named forms *T. dimorphon*, *T. congolense*, and *T. pecaudi*. Owing to the entire absence of long free-flagellated forms, and the accompanying broad individuals with well-developed undulating membrane, the last named may be excluded. We have then to discuss the properties of *T. dimorphon* and *T. congolense*, the only remaining named species, and to ascertain to which the organism from Balungu most closely approximates. It is to be noted that the 'animal reactions' in all these are closely similar.

According to the original descriptions of Dutton and Todd,† *T. dimorphon* occurs in at least two forms:—(1) a tadpole similar to that which we have just described, and (2) a long form carrying a free flagellum. Intermediate forms, termed stumpy, may also be found.

This parasite was found in the Gambia, where ten horses were detected as suffering from trypanosomiasis. Of these, four were used for experimental observation—Cases 1, 5, 6 and 9. Case 6 was brought to England and served for the experimental work carried out by Thomas and Breinl‡ and by Laveran and Mesnil.§ Practically all

* Montgomery R. E. and Kinghorn, A. *Ann. Trop. Med. Parasitol.*, 1909, II, 5, pp. 333-344.

† Dutton and Todd. *Thompson Yates and Johnston Lab. Reports*, 1903, Vol. V.

‡ Thomas and Breinl. *Thompson Yates and Johnston Lab. Reports*, 1905, Vol. VI, II.

§ Laveran and Mesnil. Trypanosomes et Trypanosomiases.

Dutton's and Todd's work was conducted on Case 1, the strain from which was not used in Europe, and it is from this animal that the microphotographs (Plate IV, figs. 2 and 3 of their Report), which clearly show the 'stumpy' and the free-flagellated 'long' forms, were made. We elsewhere analyse the published evidence on this question; here it is sufficient to say that we consider it highly probable that Horses 1 and 6 were infected with distinct trypanosomes, one of which (Horse 1) was the original host of *T. dimorphon*. The other (Horse 6) is the original host of that parasite, which we have designated *T. confusum*, which at Liverpool and Paris has been accepted as *T. dimorphon* that had undergone a peculiar morphological transformation. We hold that we have recovered *T. dimorphon* at Broken Hill, thereby reducing the strength of an argument that Dutton and Todd were concerned with an infection by such a trypanosome as that now known as *T. pecaudi*, or were misled by a mixed infection. We consider that our work at Broken Hill may be considered to substantiate the species in conformity to the original description.

For a trypanosome to be regarded as *T. dimorphon* it is necessary that it be shown to develop a free flagellum. From the observations of Dutton and Todd in the Gambia, and ourselves in Northern Rhodesia, it would appear that small experimental animals are best suited for this purpose. 'Long' forms were produced in all five of our guinea-pigs, and in three out of five white rats inoculated with this strain of trypanosome in its first, second and third passages.

In one rat, three guinea-pigs and two dogs infected by the 'Balungu' strain, we failed to notice the development of a free flagellum, or even the occurrence of forms corresponding to the 'long form' of Laveran and Mesnil. The longest specimen we measured was 16·3 μ. The evidence is negative, but with such as it is we cannot identify this trypanosome with *T. dimorphon*. It then falls into the group represented by *T. confusum* (*T. dimorphon* of Paris), and *T. congolense*. Laveran* has drawn attention to the differences between these species. He writes:—'Au point de vue morphologique, '*Tr. congolense* diffère de *Tr. dimorphon*. Le premier de ces 'trypanosomes mesure 10 μ à 13 μ de long, les exemplaires qui

* Laveran. *Annales de l'Instit. Past.*, 1908.

'atteignent 15 μ à 17 μ de long sont fort rares; *Tr. dimorphon* 'présente au contraire, dans les cas types, un mélange de 'petites formes (10 μ à 15 μ de long) et de grandes (22 μ de long en 'moyenne). . . . Mais *Tr. dimorphon* ne se présente pas toujours 'sous ses formes typiques. Dans certaines infections dues à *Tr.* '*dimorphon*, les grandes formes sont rares ou très rares; si bien qu'on 'pouvait supposer que *Tr. congolense* était une variété de *Tr.* '*dimorphon* dans laquelle les grandes formes avaient disparu. . . .' and as further substantiating Broden's species he quotes the results of 'cross inoculations' by *T. dimorphon* (*T. confusum*) into animals 'immunised' towards *T. congolense*. These observations on the morphology are in entire accord with those of Broden,* who gives a maximum measurement of 15·5 μ for his species.

The name *Trypanosoma congolense* cannot then be applied to a form which under the normal conditions of experimental observation exceeds about 17 μ in length; it differs therefore from *T. confusum*, which may attain 23 or 24 μ but which does not develop a free flagellum, and from *T. dimorphon*, which in certain forms resembles these two exactly, but which is capable of developing a distinct free flagellum upwards of 10 μ in length. The parasite which Höhnel has described under the name *T. congolense* would appear to approximate more closely with *T. confusum*.

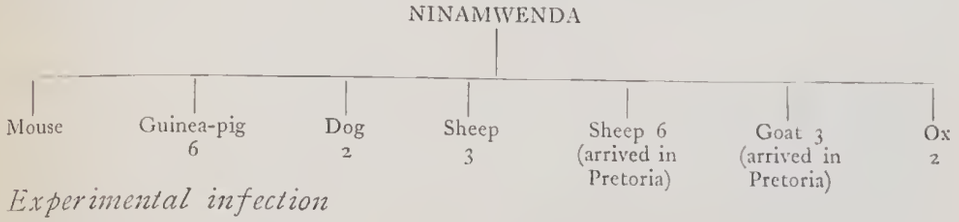
The trypanosome from Balungu has not been seen to exceed 16·3 μ; until further investigation decides that it is capable of assuming larger dimensions, in which case our conception of the classification of this group must be amended, we associate it with *T. congolense, sensu* Broden and Laveran.

B. *Ninamwenda strain.*

This cow came to Kambole in August, 1907, from the Niamkolo Mission on Lake Tanganyika, a place where cattle appear to thrive and where no sickness is recorded. In the rainy season of 1907-1908 she became extremely emaciated and lost practically all her hair, but regained condition and coat in the spring of 1908. At examination on October 1st, she was not particularly thin, and was said to be improving; trypanosomes, one in fifteen fields, were seen, and they

* Broden. *Rap. Lab. Leopoldville*, No. II, 1906.

were present at each succeeding examination till our departure. The owner and the herdsman considered her to have recovered her original good health, and said she gave a normal amount of milk and nourished her calf well. The following inoculations were made from this animal :—



Experimental infection

Grey mouse caught locally. Inoculated October 23rd with 0·4 c.cm. direct from Ninamwenda. No trypanosomes were seen in its blood up to November 6th, when it escaped.

No rats were available for inoculation.

Guinea-pig.—October 8th, 1908. Inoculated intraperitoneally with 10·0 c.cm. blood of Ninamwenda. Trypanosomes were not seen at almost daily examinations until November 3rd—the 26th day. They disappeared for five days tben returned, being present at each subsequent examination in numbers varying from 1 in ¼ cover-glass to 1 in a field—an average would be one to eight or ten fields. The animal maintained its condition well, despite the rough usage and exposure on the march, and was accidentally killed on January 3rd, 1909. There were no abnormal lesions on autopsy, and the body was well nourished and fat.

Dog 2.—October 8th, 1908. Inoculated intraperitoneally with 10·0 c.cm. blood of Ninamwenda. From the 8th day the temperature became irregular and jerky, and the dog lost condition, acquired a harsh coat and appeared depressed. A month after inoculation there was considerable oedema of the sub-maxillary space and a catarrhal discharge from the eyes. He died in an emaciated state on November 29th (52 days), without ever showing trypanosomes in his blood or on gland puncture. Post-mortem showed only general enlargement of all lymphatic glands, and considerable oedema in the connective tissues of throat and in the body cavities. The spleen appeared normal. No sub-inoculations were possible, but a careful search failed to show trypanosomes in any organ.

Sheep 3.—An aged male. October 8th, 1908. Inoculated subcutaneously with 1·0 c.cm. blood of Ninamwenda. Trypanosomes first appeared on the 23rd day at which time the temperature rose slightly. They were then present daily, with two exceptions, till the animal was destroyed on our leaving for home. They were never numerous—1 to two fields being highest recorded, and the temperature was but slightly irregular, 104·8° maximum.

Sheep 6.—October 23rd, 1908. Inoculated intraperitoneally with 3·0 c.cm. blood of Ninamwenda. Trypanosomes, 1 to ¼ cover-glass, were seen in the 11th day; on the 12th, 13th, 14th they were absent, but reappeared on the 15th, from which day they were always present in small numbers—1 to 10 fields maximum. The temperature showed very little irregularity, and the animal travelled well, reaching Pretoria in January in good condition, and according to Dr. Theiler's letter of April 26th, was then still alive.

Goat 3.—About three months, still with its mother. October 23rd, 1908. Inoculated intraperitoneally with 3·0 c.cm. blood of Ninamwenda. One trypanosome was seen on the 19th day, but not again during the regular examinations. On the march they were seen twice in five observations and were

present on this animal's arrival in Pretoria. There was no apparent loss in condition and no symptoms were manifested, and this animal was alive on April 26th, 1909.

Ox 2.—1½ years old. October 23rd, 1908. Inoculated subcutaneously with 5·0 c.cm. blood of Ninamwenda. The temperature rose on the eighth day to 103° and continued in that neighbourhood to the 17th, when it rose to 105·2°, falling again on the 25th when temperatures were ceased. Trypanosomes were seen in the blood on the 10th day, and were thereafter present daily, ranging from 1 to 3 to a field. Gland puncture had shown the infection three days prior to their appearance in the blood. No symptoms were noticed in the animal during the three and a half weeks of observation, and we have received no further report as to his present condition.

At Pretoria, inoculations were made from both Sheep 6 and Goat 3. Dr. Theiler informs us on April 26th that from the former animal both the guinea-pig and the rabbit became infected, from the latter the guinea-pig is positive, but the rabbit is negative.

Morphology of the 'Ninamwenda' Trypanosome

In fresh preparations the trypanosomes from this cow and also from a second (Nakakoti) were clearly distinct from those of the *T. congolense* type seen in Balungu. They appeared as slightly elongated, egg-shaped bodies, moving across the field with the flagellar extremity in front, and rarely showing any movement of the body, even when held up by corpuscles. They easily traversed the field of vision, but at a rate at which they were readily followed.

Stained by Leishman's method, they measured from 11 to 19 μ in length, the latter representing divisional forms (average 14·66 μ), and from 2·9 to 3·75 μ in breadth (average 3·38 μ). The mean of a series of measurements is:—

	Extremity to Nucleus	Nucleus	Nucleus to flagellar extremity	Portion of free flagellum
	5·45	2·36	5·1	1·7
(In Nakakoti)	4·97	2·26	4·89	1·48

In Nakakoti the average width was 3·58.

The blepharoplast is almost terminal or up to 0·8 μ from the end. The rounded or oval nucleus is almost centrally placed. The undulating membrane is represented by a narrow band running parallel to the body, being better developed in the narrower forms. The rather well-defined rim is continued as a bristle-like projection of up to 1·7 μ in length, hardly amounting to a flagellum, but free of ectoplasm. The posterior extremity is rounded or very bluntly angular, the flagellar abruptly drawn out. The cytoplasm stains a deep pink, and commonly shows a large and most distinct vacuole just posterior to the nucleus. Though not always present, or not so prominent, this

was of very frequent occurrence, as also was the existence of chromatic granules at both poles of the nucleus.

Diagnosis

The picture presented by the trypanosomes is striking, and dissimilar to all other forms; the ratio of breadth to length (1 : 4), the round aflagellar extremity and the narrow undulating membrane giving it a characteristic shape.

On careful examination of some slides (Ninamwenda) a few forms are seen which individually would be considered as not unlike a broad tadpole of *T. nanum* or *T. congolense*, but they are most exceptional (the smallest is seen on Plate IV, fig. 1). In the successful sub-inoculations at Kambole (guinea-pig, sheep, goat, and ox) only the characteristic broad forms were seen. Sheep 6 and Goat 3 were taken to Pretoria, where it was found that the latter was still showing this type. The trypanosomes in Sheep 6 were identical morphologically with the tadpoles of *T. nanum* or *T. congolense*. We are quite unable to explain this at present. The change may be due to a natural alteration in the morphology, or to a secondary infection acquired on the march down. During the journey of six weeks from Tanganyika to the railway these animals were carried in large fly-proof cages, so that *Glossina* may be absolutely excluded. In country known to be free from tsetse they were allowed out for a short time on arrival in camp at night, and it might be considered possible for infection to have then occurred; or, as three sheep or goats were taken in each cage, it may have resulted without liberation. It is hoped that Goat 3 may serve as a control to this change: with both animals in Pretoria, an exact and exhaustive comparison may be made. Until this has been accomplished we hesitate to do more than assign this trypanosome to the group containing *T. dimorphon*, and note that in the original and all sub-inoculated animals at Kambole it presented morphological features unusual in the other members of the group, features which if maintained in successive passages would warrant a conclusion that this trypanosome differs from previously described species.*

* I have been authorised by Dr. Laveran to say that he has examined the preparations of Mr. Montgomery and Dr. Kinghorn, labelled '*Ninawenda strain*,' coming from a Rhodesian cow.

Dr. Laveran adds, 'Le trypanosome est voisin de *Tr. congolense* mais beaucoup plus large que ce dernier, ce qui permet de croire qu'il s'agit (encore!) d'un espece nouvelle.' He proposes if the trypanosome is really a new species, to call it *Tr. montgomeryi*, and I may add that Dr. Kinghorn agrees to this proposal.—R. Ross.

Trypanosomes Occurring in Naturally Infected Dogs

A. *The 'Chunga' Trypanosome.*

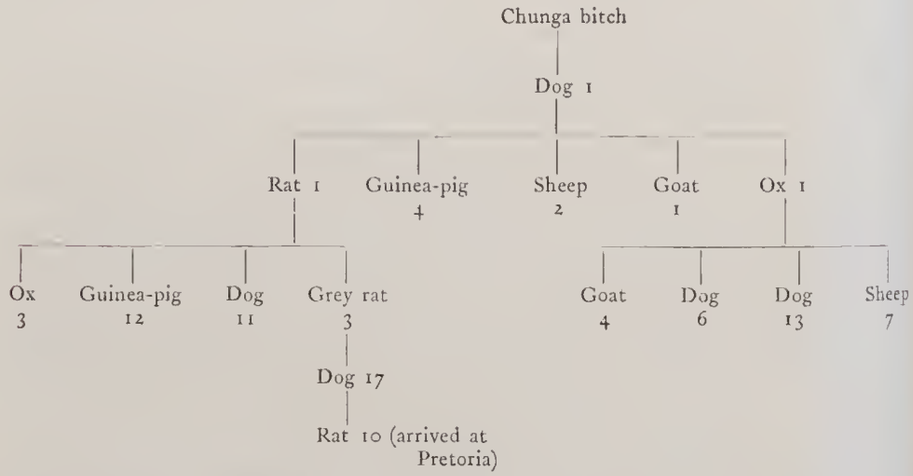
Origin. This strain was derived from an Airedale bitch which was brought North from Cape Colony at the end of May. If left the railway on July 7th. On the 5th August the owner, who was travelling with her, noticed she was getting rather weak, and that her milk was diminishing—this was ascribed to the litter of pups which had been born on July 18th—but she appeared to regain her condition. On August 27th an opacity of the right cornea was noticed, and examination on September 4th at Chunga Farm showed trypanosomes.

Tsetse flies (*Gl. morsitans*) might have been encountered within a few days of the railway. They appear to be constantly present in a district (Mpika) entered on August 1st; and it would seem possible for infection to have taken place then.

We were informed that this bitch was destroyed *in extremis* on September 11th, a week after diagnosis.

A healthy native dog was inoculated from this bitch and was carried to Kambole, serving as the origin for the experimental work possible; it was, however, rather our desire to maintain the strain for future investigation under suitable conditions.

The following is the genealogy of the strain:—



Experimental infection

Rat 1.—This animal had been inoculated on May 9th with 'Scotsdale' strain without result.

September 24th. Received intraperitoneally three drops blood of Dog 1. Trypanosomes appeared on the fifth day and were constantly present till death on November 9th (46th day). Ten days before death there were incoördination of the hind legs, and a muco-purulent discharge from the conjunctivae.

Rat 10.—Was inoculated subcutaneously with 0·5 c.cm. heart blood of Dog 17 just dead, on December 31st. No further examinations were made till the animal arrived in Pretoria, when organisms were very numerous. It was still alive on January 23rd.

Grey Rat. 3.—Caught locally. Inoculated subcutaneously November 9th, 1908, with 0·5 c.cm. blood of Rat 1. Trypanosomes appeared on the fourth day and were constantly seen up to death on December 14th, the 35th day.

Guinea-pig 12.—This animal had been unsuccessfully inoculated with 'Scotsdale' strain in May, 1908.

November 3rd, inoculated with eight drops blood Rat 1, and on this rat's death, November 9th, received the heart washings. Trypanosomes were seen on November 13th, ten days after first inoculation. They were present later at various times up to death, which took place on December 23rd, and was probably due to a poisonous grass in the food (vide Scotsdale guinea-pig). Trypanosomes were not seen on autopsy, and the body was well nourished.

Guinea-pig 4. An animal which had resisted infection by *T. vivax* a year previous.

September 24th, 1908. Inoculated intraperitoneally with three drops of blood from Dog 1. The animal remained in perfect health, and trypanosomes were never seen at frequent (every two days) examinations up to November 5th. Organisms were first seen on November 5th, and were thence present at most subsequent examinations till death on December 17th, which was without doubt accelerated by frequent exposure to the rains and cold weather and by constant travelling.

Dog 1.—A young native bitch. Inoculated subcutaneously September 5th, 1908, with twelve drops blood of original case. Organisms were not seen on September 12th, the only examination prior to arrival at camp, September 22nd. From this date to that of death, October 18th (thirty-three days), trypanosomes were constantly present. Beyond emaciation and weakness no special symptoms were observable—there was no corneal opacity as in the original animal. The temperature was constantly elevated to 102° to 103°, and showed no paroxysmal tendency.

Dog 6.—October 30th, 1908. Received 6·0 c.c. subcutaneously of this strain passed through Ox 1, trypanosomes 1-4 fields. It did not become infected, and died of pleuro-pneumonia on December 21st.

Dog 11.—November 1st, 1908. Inoculated subcutaneously with twenty drops blood from Rat 1. Temperature commenced to rise on the fifth day, and trypanosomes one to a field were seen on the sixth. During the time it was taken, the temperature was considerably elevated, reaching 105·4°, and trypanosomes were constantly present till death on December 10th (forty days).

Dog 13.—This dog served as a control to Dog 6, which did not become infected after inoculation from Ox 1. November 9th, 1908. Inoculated intraperitoneally with 30 c.c. from Ox 1 (trypanosomes 1-30 fields). The temperature commenced to rise on the fifth day, and trypanosomes were seen on the seventh and at succeeding examinations up to death on November 27th—18th day.

Dog 17.—December 14th. Inoculated subcutaneously with heart blood of Grey Rat 3. Trypanosomes were very numerous at the first examination on the eighth day. The disease was acute and the dog died on December 31st—16th day

Sheep 2.—September 29th. Inoculated subcutaneously with three drops blood of Dog 1. Trypanosomes one to a cover were seen on the eleventh and twelfth day, when the animal was destroyed.

Sheep 7.—November 14th. Inoculated intraperitoneally with 10·0 c.c. blood from Ox 1. The object of this experiment was to note whether the morphological forms present in this Ox would reappear. Trypanosomes 1 in ¼ cover-glass were seen in the blood on one occasion only (December 15th): they were present in the glands on December 1st, 10th and 23rd, and not seen on December 14th. This animal died in the train on January 8th, and was too decomposed for inoculation on arrival in Pretoria the following day.

Goat 1.—An adult female. September 30th. Inoculated subcutaneously with three drops blood from Dog 1. The temperature rose on the sixth day and again on the tenth (106·8°), from which date it was almost continually elevated above 104°, and after the fifth week was over 105°. Trypanosomes were only seen twice on direct examination of the blood—1 to half a cover-glass (¾-inch) on each occasion— the 18th and 27th day. They could constantly be found on puncture of the prescapular glands. No symptoms were noted beyond slight emaciation, the animal retaining its strength until it was destroyed on our leaving for home.

Goat 4.—Adult female. October 30th was inoculated subcutaneously with 4·0 c.c. blood from Ox 1. The temperature commenced to rise on the fourth day and continued irregular, but always elevated between 103° and 107°, till it was destroyed on November 15th. Trypanosomes were never seen in the peripheral blood; but they were constantly present in the prescapular gland from the seventh day.

Ox 1.—A five-year-old cow. Had been under observation for eighteen days prior to inoculation, during which she was in perfect health and her temperature had never exceeded 102°.

October 18th, was inoculated subcutaneously with 8·0 c.c. from Dog 1, just dead. The temperature commenced to rise the following day (103·2°). On the third day it was 105°, and 106° on the fourth after inoculation, and then fell to 103·2°. For a week it continued irregular, showing a daily variation of two to three degrees, later becoming more even, but ranging daily from 101·5° to over 103°. Trypanosomes were first seen 1 to half a cover-glass on October 24th—the sixth day—and they were thereafter continually present, averaging one to ten fields: on two occasions only did they exceed one to a field. There was therefore no periodicity in either temperature or organisms; and no increase in numbers when a high temperature (106·2°) was registered early in the infection. Gland puncture showed trypanosomes two days prior to their appearance in blood. During the four weeks of disease she was under observation, there was noticeable emaciation, the animal being in very good condition at the time of inoculation. At our departure she was left under the charge of a neighbouring European; but up to date we have no report as to her condition.

A suspicion was aroused that by some means a mixed infection might have occurred, and a series of inoculations was carried out to ascertain this point. We were, however, unable to obtain any evidence of such an occurrence.

Ox 3.—1½ years old. This Ox was inoculated to see whether the trypanosomes noted in Ox 1, which were suspected as being foreign to the inoculation, would again reappear.

October 31st. Inoculated subcutaneously with 20 drops blood from Rat 1. There was a slight thermal reaction sixth and seventh days—from then to the fifteenth, the day we left, it continued normal. No trypanosomes were seen in the peripheral blood during this period, but gland puncture was positive from the seventh day. We have no report as to the present condition of this Ox.

Morphology of 'Chunga' Trypanosome

(*a*) *In original case*

In fresh preparations the trypanosomes were long and caused considerable disturbance among the corpuscles; they remained localised to the field.

Stained, two main types were discernible.

1. A 'long' form measuring from 24·75 to 30·3 μ in length (average 26·9 μ) by 1·5 to 2·0 μ in width. An average measurement of a series is:—

Extremity to Blepharoplast	Blepharoplast to Nucleus	Nucleus	Nucleus to extremity	Free Flagellum
3·25	5·62	3·75	5·62	8·74

The body is narrow, the posterior extremity drawn out into what Balfour describes as a 'pike's head'; the other is continued as an ectoplasmic prolongation for a variable distance along the flagellum; the cytoplasm stains faint bluish and is relatively free from granules or vacuoles. The blepharoplast is removed about 3·0 μ from the extremity, and the elongate nucleus (3·75 × 1·5) lies well to the flagellar end of the body. The undulating membrane is fairly well developed, though hardly so much so as is usual in *T. evansi*; the rim is continued as a free flagellum varying from 6 to 11 μ in length, clear of all ectoplasm.

2. 'Short' forms measuring from 17·15 to 21·9μ in length (average 19·0 μ) by 2 to 3·5 μ (average 2·6 μ) devoid of a free flagellum, or having only a beak of one or two micra. The following is the mean of a series of measurements:—

Extremity to Nucleus	Nucleus	Nucleus to flagellar extremity
6·55	2·2	10·25

The body is relatively broad; the posterior extremity is bluntly angular or sometimes rounded; in a few cases it showed evidence of being drawn out. The cytoplasm stains more pink than is seen in the 'long' forms, and granules, though rare, are of more common occurrence; vacuoles were not noted. The blepharoplast is removed from 0·7 to 1·5 μ from the extremity or may be almost terminal.

The nucleus is round and lies slightly on the aflagellar side of the middle. The undulating membrane exists, but is not well developed, and the rim ceases with the body, or may be continued in a few instances for as much as 4 μ.

In this dog, the long forms greatly exceeded in number the short, at the time of examination. Intermediate forms were very uncommon.

(*b*) *In experimental animals.*

(i) In the *rats*, *guinea-pigs* and *dogs* both forms were seen but the short was usually in numerical excess of the large; this latter was not seen in certain slides from Dog 11, and in some others it was very rare. In Rat 1 they co-existed in almost equal numbers.

(ii) The extreme rarity of occurrence in the blood of *sheep* and *goats* precluded a study of the forms; in smears made from gland punctures they respond to the 'short' forms, but the length is greater (average 23·2); the free flagellum was rudimentary.

(iii) In *cattle*. In fresh preparations the motility was found to vary from day to day, and also in individual trypanosomes. Most commonly the form which re-appeared was almost as active as that to which we have referred as *T. vivax*; less frequent were those trypanosomes whose gliding movements without corpuscular displacement could be watched while crossing a field. Only rare were those even temporarily remaining in a single field.

In stained preparations we have only seen one form. This trypanosome showed morphological variations from those in other animals inoculated with this strain. It measured from 21·75 to 25·5 μ in length (average 22·4 μ) and from 2·7 to 4·5 μ in breadth (average 3·3 μ). The following is the mean of made measurements:—

Extremity to Blepharoplast	Blepharoplast to Nucleus	Nucleus	Nucleus to body extremity	Free Flagellum
0·7	5·8	3·3	7·3	5·52

The body is rounded or bluntly conical at the posterior extremity, and tapers gradually from the widest point, which is close to the region of the blepharoplast. The cytoplasm is commonly homogeneous and free from chromatic granules or vacuoles. The blepharoplast is

large and 1·0 μ from the end, but frequently it is almost terminal; the nucleus is compact, round or somewhat oval, and situated towards the middle of the body. The undulating membrane is represented, as in *T. vivax* and most of the long forms of *T. nanum*, by a narrow band extending parallel to the margin of the body; its rim is continued as a free flagellum of from 4·0 to 6·0 μ.

In its morphology this trypanosome so closely resembled that which we described as *T. vivax* at Broken Hill that we suspected a mixed infection—a suggestion accentuated by the rapid rise in temperature after inoculation, and by the failure to infect Dog 6. *T. vivax* was not rare in the blood of inoculated sheep and goats, while, as indicated by Sheep 2 and Goat 1, the Chunga organism was uncommonly seen. Goat 4, Sheep 7 and Dog 13 were inoculated from this cow; the two ruminants became infected without showing numerous trypanosomes in the blood (observation on Goat 4 limited to fifteen days; no peripheral organisms seen, though gland puncture positive); the dog became infected with trypanosomes identical to those seen in the original and sub-inoculated dogs, the short forms markedly preponderating. As a control to these experiments a second ox was inoculated with this strain passed through a rat. Unfortunately we had to leave for home before this animal showed peripheral trypanosomes; but a comparison of forms seen in gland-puncture specimens from these two bovines did not reveal any appreciable differences. We are therefore led to consider it possible that the Chunga strain passed into a bovine may manifest this morphological variation, and that the failure to infect Dog 6 was due to individuality.

Diagnosis

Owing to lack of comparative study we are unable to assign this trypanosome to any particular species. In our original dog and in several of the sub-inoculations it shows considerable affinity in both morphology and animal reaction with the *T. evansi* group, and we have spoken of it as allied to *T. brucei*. In the strain of *T. brucei* maintained at Runcorn, forms corresponding to both 'long' and 'short' are found—the so-called 'male' and 'female'—but on an average they are larger, and more transitional stages can be made out. It will at once be remarked by one conversant with Laveran's

work* that the description we have given of the 'Chunga' trypanosome shows a marked similarity to *T. pecaudi*. It is to be observed, however, that we have never seen a trypanosome of 14·0 μ; our smallest was 17·15 μ; the undulating membrane in our form is less developed than that figured by Laveran, and we have the more common occurrence of a small flagellum. This trypanosome is maintained at Pretoria, and additional work will make its position clearer.

B. *The 'Wallace' trypanosome*

In September we examined an Irish terrier which had accompanied the Administrator, Mr. Wallace, on tour from Fort Jameson. Trypanosomes were present in his blood, but the dog died and was destroyed before we got an inoculation. Mr. Wallace thereupon very kindly telegraphed to Fort Jameson for two dogs to be sent in charge of messengers to follow the same route. These dogs, born in Fort Jameson, and apparently in perfect health, left there on September 24th and travelled *via* Nawalia, Mpika, Kasama and Abercorn. One reached our Kambole camp on October 29th; the other is said by the messengers to have died of extreme weakness two days before.

This dog 'Dip,' a short-haired animal of about 35 lbs. weight, was in hard condition on arrival from the long march; on casual glance he was quite healthy and strong, only his membranes were somewhat pale. Trypanosomes were present in his blood.

The dog refused food on November 1st, and on the 2nd was unable to stand and was semi-comatose; his coat was staring and respirations increased. During the morning he had five epileptiform fits, lasting one-half to three-quarters of a minute, during which he made violent attempts to rise, and snapped at any near object, howling and attempting to bark whilst the fit lasted. As no improvement was noticed, he was destroyed by an intrapleural injection of hydrocyanic acid at four o'clock. During these few days his temperature had not exceeded 102·5°.

Autopsy. Membranes and subcutaneous tissues somewhat pale, but not excessively so. There was no increase of fluid in the body cavities. Lymphatic glands were all enlarged, slightly oedematous and congested. Other organs

* Laveran. *Annales de l'Instit. Past.*, 1907.

healthy-looking, except the spleen, which was of enormous size: it extended right across the abdomen and measured over three inches in width at the narrowest part, and was thickened to an extent of nearly two inches; the substance was soft and friable, and the Malpighian bodies large and prominent.

Experimental infection

The following inoculations were carried out:—

Rat 8.—October 30th, 1908. Inoculated subcutaneously with 2·0 c.c. blood of 'Dip.' Trypanosomes appeared on the fifth day and increased in numbers to death on November 10th.

Guinea-pig 10.—October 30th, 1908. Inoculated intraperitoneally with 7·0 c.c. blood of 'Dip.' No trypanosomes were seen up to November 15th. They were present on November 22nd and at succeeding examinations to death, which occurred on December 7th (38th day).

Guinea-pig 13. December 7th. Inoculated intraperitoneally with 1·5 c.c. blood direct from Guinea-pig 10. Trypanosomes were seen on December 12th and the animal died on December 14th, a date on which several of our guinea-pigs died, as a result, we think, of some vegetable irritant in the food.

Dog 12.—November 2nd. Inoculated subcutaneously with 5·0 c.c. heart blood direct from 'Dip' on post-mortem. The temperature rose on the sixth day, and trypanosomes were present. They increased in numbers, and the temperature continued to rise up to death on November 13th, the eleventh day.

Dog 14.—Was inoculated subcutaneously with 3·0 c.c. blood of Dog 12 on November 13th. No trypanosomes were seen up to December 7th, when he was stolen or lost.

Dog 15.—Was inoculated subcutaneously on December 14th with 2·0 c.c. heart blood of Guinea-pig 13 immediately after death. No trypanosomes were ever seen in the blood of this animal, which arrived in Pretoria looking well.

Morphology of the 'Wallace' Trypanosome

In fresh preparations the actively moving organisms remain localised to the field and rarely attempt to travel; they recall the forms seen in Balungu (Plate IV, fig. 4).

Stained, they present the ordinary appearance of a 'tadpole' trypanosome, measuring from 8·8 to 15·3 μ (average 12·3 μ) in length, and from 0·9 to 1·75 μ in width. The following is the mean of the measurements:—

Extremity to Nucleus	Nucleus	Nucleus to flagellar extremity
4·4	2·1	5·8

The small blepharoplast is removed a short distance in most individuals. The nucleus, compact and deeply staining, is oval or compressed. The undulating membrane and free flagellum are absent or very rudimentary. The aflagellar extremity is rounded; in some of the larger forms it becomes more pointed.

The morphological appearances in the first dog and in the sub-inoculations from this are identical; no 'long' forms were seen in any animal.

Diagnosis

The animal reactions of this trypanosome, though limited in number, indicate a degree of pathogenicity not seen in *T. nanum*, while the absence of any long form would appear to negative *T. dimorphon* or *T. confusum*. We consequently associate this trypanosome with *T. congolense*.

The subject was a small wire-haired fox terrier 'Jock' which accompanied one of us throughout his stay in the country. The history of this dog is of interest as showing the resistance enjoyed by some dogs towards infection by *Glossina*.

He was in contact with *Glossina morsitans* or *Glossina palpalis* almost daily from September, 1907, to February, 1908, and again from April to the end of May, and during the last week in August, 1908. In March, 1908, he became weak and listless, with pallid membranes and a temperature up to 103°, but no trypanosomes could be demonstrated, and a rapid recovery was made. From the middle of October he again manifested signs of illness, commencing here with marked oedema of both ears; a few days later he had a temperature of 102°, rapid respirations, nose dry and warm, and visible membranes pallid. Trypanosomes were first seen on October 31st, and on only three other occasions during the next fortnight of daily examinations. He appeared to improve from November 24th, and no trypanosomes were seen after November 12th. He was left at Pretoria apparently improved, but Dr. Theiler tells us he rapidly went off and died, showing many trypanosomes shortly after our departure.

A dog (No. 9) was inoculated on October 31st with six drops of blood from 'Jock.' The temperature became irregular from the eighth day, but no trypanosomes were seen in the blood until November 21st: they were present in the glands from the tenth day following inoculation. Trypanosomes remained present, but always scanty (one or two to a cover-glass, rarely one in ten fields), up to death on November 27th.

Dog No. 16 was inoculated subcutaneously on November 27th with 1·5 c.c. heart blood of Dog 9. Trypanosomes were never seen in the blood of this animal up to its arrival in Pretoria; but gland puncture on December 20th showed infection to have resulted.

Morphology of the 'Jock' Trypanosome

In the original and the sub-inoculated dog the parasite seen corresponds in every way with that already described in 'Dip' and in 'Balungu'; to this description we have nothing to add.

Trypanosomiasis Occurring in a Naturally Infected Pig

On October 7th we received from a European in Abercorn a young male pig for experimental purposes. This animal was one of a litter born in May at Abercorn, where within fifty miles *Glossina morsitans* or animal trypanosomiasis have never been seen or suspected, and where there is no traffic to introduce it. On arrival this animal was footsore and dull, but this was ascribed to the conduct of the native who drove it to us a distance of fifty miles in two days. It was kept in our camp and appeared quite healthy until October 31st, when the native in charge reported it sick. On examination it was recumbent, semi-comatose, breathing heavily, visible membranes injected, considerable oedema of the prepuce and a temperature of 102°. Trypanosomes were swarming in the blood, and the animal died six hours later.

Autopsy commenced immediately. Oedema of prepuce; all subcutaneous vessels markedly congested; body fat plentiful.

The same marked congestion in all mesenteric veins: liver and kidney slightly congested. Spleen considerably enlarged, soft and friable, with Malpighian bodies prominent. Some excess of blood-tinged fluid in the pericardium; coronary vessels of heart greatly distended. Ante-mortem clots in both auricles and ventricles. Blood dark and clots readily; lungs pale.

All lymphatic glands swollen, soft and excessively haemorrhagic.

The picture presented was that of very acute haemorrhagic septicaemia.

We are quite unable to say where infection was derived; the sudden death indicated rapid disease due to a local infection after arrival in our camp. This could not be entirely excluded owing to existence of *Stomoxys*, *Hematobia* and *Tabanus* in small numbers; but the pig had been in intimate association with only Ox 1, which had an infection with a trypanosome (Chunga) morphologically distinct, and which only became infected five days prior to the pig's death. From the fact of its indisposition on arrival we might surmise a previous infection from some as yet unknown source in Abercorn. There the pig had been in intimate contact with sheep, the histories of which are always uncertain owing to the possibility of traffic in

these animals, and which, as we have already noted, may be a great source of danger.

An enquiry into the morphology and animal reactions of the trypanosomes met with, and a comparison with those on our camp previously, might aid towards a possible solution. We are only able to give a summary of the few reactions obtained prior to the arrival of the strain in Pretoria; it being our main object to preserve it for experimentation in suitable surroundings.

Experimental.

All inoculations made direct from the pig.

Rat 9.—October 31st. Inoculated intraperitoneally with 5·0 c.c. blood. No trypanosomes were ever seen, and this animal arrived at Pretoria in good condition.

Guinea-pig 11.—October 31st. Inoculated intraperitoneally with 5·0 c.c. blood. Trypanosomes were never seen. It died on December 19th, probably from exposure. There were no indications of trypanosomes on post-mortem.

Dog 10.—October 31st. Inoculated intraperitoneally with 5·0 c.c. blood. During two weeks of observation the temperature remained normal, and organisms were not seen on blood or gland examination. On the march they were not encountered at various examinations. Death took place from pneumonia on January 3rd. There were no indications of trypanosomes on post-mortem.

Goat 6.—October 31st. Inoculated subcutaneously with 5·0 c.c. blood. The temperature rose to 106·4° on the fifth day, and for the remaining ten days of observation assumed the type met with in Broken Hill.

Trypanosomes, one in five fields appeared on the eighth day, were absent on the ninth and tenth (temperature low), were seen two in quarter cover-glass on the eleventh (temperature 107·2°), absent the twelfth (temperature low), and were again present on the next thermal elevation on the 13th day. There consequently appeared to be a connection between temperature and presence of organism.

This goat travelled well, and arrived in Pretoria in good condition. Trypanosomes were not seen in the peripheral blood on the journey, but a gland puncture on December 21st showed them still present. At Pretoria (January, 1909) a rabbit, guinea-pig and a sheep were inoculated, and on April 26th Dr. Theiler informs us that the original goat is still alive, that the sheep is infected, but the rabbit does not show anything.

Morphology of the 'Pig' Trypanosome

The trypanosomes present at death of the original host were so numerous that no details of movement could be made out; this more especially, too, since they were agglutinating. In the goat they could be seen crossing the field without difficulty, giving the impression of a gliding motion.

In stained preparation. (1) *Pig.* The trypanosomes measure from 11·5 to 17·9 μ in length and from 1 to 1·8 μ in breadth. The

majority of forms seen were in a state of active multiplication, so accounting for the average length of 15·75 μ. The mean length of single individuals was 13·15 μ. In these latter the cytoplasm was relatively clear and homogeneous, the blepharoplast some 0·5 μ from the rounded or bluntly angular extremity; the nucleus rounded and rather loose in texture being centrally placed. There is a slightly better development of the rudimentary undulating membrane than is usual in these 'tadpole' trypanosomes, but practically no free flagellum.

In divisional forms the aflagellar extremity was more pointed, and vacuoles were seen in the cytoplasm of many. The undulating membrane was better developed, amounting almost to that common in *T. lewisi*, and a free extremity to the flagellum of 2 or 3 μ was seen in several individuals. Where this portion could not be designated 'free,' this extremity of the body or the ectoplasm was drawn out more than in the smaller single forms.

(2) *Goat.* In this animal the trypanosomes which appeared measure from 14·5 to 17·25 μ (average 15·97 μ) in length and 1·5 to 2·6 μ in breadth (average 1·83 μ). The following is the mean of a series of measurements:—

Extremity to Blepharoplast	Blepharoplast to Nucleus	Nucleus	Nucleus to flagellar extremity
1·4	4·6	2·47	7·5

No free flagellum was seen, but, as in the pig, the flagellar extremity of the body was in some cases drawn out. The cytoplasm stained rather pink, and granules or vacuoles were infrequent. The aflagellar extremity is rounded, but more elongated than in the tadpoles of *T. congolense*. Dividing forms (up to 17·25 μ) were present, and in these there is some approach to a very small undulating membrane, which in the solitary individual is as rudimentary as in 'tadpoles.'

Diagnosis

From the morphology of this trypanosome it would appear that we are dealing with either *T. congolense* or *T. nanum*. The animal experiments are limited, but a dog, a rabbit (at Pretoria), a guinea-pig and a white rat remained healthy after large doses of heavily infected

blood, which, from the acuteness of the pig's sickness, might be considered of a virulent nature.

Our observations are too limited to identify this trypanosome with certainty as *T. nanum*, which is characterised by negative features; but we incline to the opinion that future work will show they are closely related.

We can now consider the question of where this pig derived infection, and at once a local origin, a transmission from the Scotsdale strain which was being maintained, will suggest itself. *T. nanum* was not found locally and was unknown around Abercorn; and though its existence there cannot be denied, and is on some grounds to be suspected, it appears more probable that this pig acquired the disease after arrival at Kambole, where *Stomoxys* and *Haematapota* were common.

VII. EXAMINATIONS OF GAME

Wherever possible an examination was made of all wild animals ranking as game which we shot, or which had been killed in the vicinity of our camps by others.

In most cases this consisted of examining the blood taken from the ear or heart in fresh cover-glass preparation; but latterly gland juice, and sometimes also that of other organs, was also examined. In no instance was blood or other fluid centrifuged. Inoculations into small animals were only made from those showing flagellates and from a wart-hog and a buffalo shot by Dr. Yale-Massey close to our camp at Broken Hill. Dry slides were made from some, and were examined stained for the presence of other blood parasites such as piroplasma and spirochaeta. These have not yet been properly examined, but no findings are recorded up to date.

The majority of these animals were killed at considerable distances from camp, and several hours elapsed before examination; but not a few, as for example those shot on the march, came under the microscope within an hour.

Bruce has indicated that direct examination is of small value; but the positive findings of Dutton and Todd and ourselves show that peripheral organisms may be present. The ideal system, however, would be to establish temporary camps in various districts with a

plentiful stock of healthy animals carefully protected in fly-proof cages at hand, and to inoculate such immediately on the death of the game, or to convey citrated blood back with as little delay as possible. This would have to be carried out in both clean (fly-free) and tsetse infested districts; and it is one of the first problems in the etiology of trypanosomiasis that should be undertaken. In Northern Rhodesia, and elsewhere, considerable difficulties will be experienced owing to the non-pathogenicity of certain endemic trypanosomes towards the ordinary laboratory animals; it would appear almost imperative, therefore, that sheep and goats should be employed.

In addition to game, wherever possible all small animals such as mice, rats, moles, bats, snakes, lizards, birds, as well as crocodiles were examined. Trypanosomes were seen only in a species of bat; no blood parasites were observed in the crocodile.

The following is a list of the game examined. It has not been deemed necessary to publish the localities wherein each was shot; it is enough to say that they were obtained in both clean and fly-infested districts:—

Elephant ...	*...Elephas africanus*	2
Hippopotamus	*...H. amphibius*	1
Buffalo ...	*...Bos caffer*	1
Eland ...	*...Tragelaphus spekei*	2
Sable Antelope	*...Hippotragus niger*	1
Roan Antelope	*...Hippotragus equinus*	13
Zebra ...	*...Equus burchelli*	11
Hartebeest ...	*...Bubalis lichstensteini*	18
Sessaby ...	*...Damaliscus lunatus*	4
Waterbuck ...	*...Cobus ellipsirymnus and C. defasa*	9
Puku ...	*...Cobus vardoni*	34
Lechwe ...	*...Cobus lichi*	2
M'pala ...	*...Aepiceros melampus*	3
Reedbuck ...	*...Cervicapra arundinum*	30
Bushbuck ...	*...Tragelaphus scriptus*	4
Oribi ...	*...Oribia scoparia*	8
Wart-hog ...	*...Phacochoerus aethiopicus*	11
Bush pig ...	*...Potomochoerus chaeropotomus*	2
Duiker ...	*...Cephalopus grimmi*	1
Lion ...	*...Felis leo*	1

Of these 158 three only showed flagellates, in two they were recognised as trypanosomes; that in the third does not belong to this

genus, and will be described independently. All these animals were shot in districts infested by *Glossina morsitans*.

1. Bushbuck, *Tragelaphus scriptus*. A young male in good condition, shot November 10th, 1907, at N'tampwa, some forty miles south-west of Ndola in North-Western Rhodesia.

The heart blood was examined about one and a half hours after death, and trypanosomes about one in ten fields seen in fresh preparation. A white rat was inoculated at once with 2·0 c.cm. intraperitoneally, but never became infected and was killed by *T. congolense* eleven months later.

Morphology of the trypanosomes. In fresh preparation the movement was limited to the field. Stained, the following is the mean of ten measurements:—

Extremity to Nucleus	Nucleus	Nucleus to flagellar extremity
4·31	1·9	5·85

The picture, then, is one of a tadpole trypanosome, which may be associated with *T. dimorphon*, *T. confusum*, *T. congolense* or *T. nanum*. The failure to obtain this strain in the inoculated rat leaves its identity uncertain.

2. Hartebeest, *Bubalis lichtensteini*. An adult male in normal good condition, shot on the 8th December, 1907, about twenty miles north of Ndola. The heart blood was examined within two hours of death. Filaria present (they are apparently fairly common in this antelope), and two trypanosomes were seen in two fresh cover-glass preparations. A white rat was inoculated intraperitoneally with 1·5 c.cm., but never became infected. In fresh preparation the trypanosome was localised to the field and produced but scanty movement among the corpuscles. It was apparently short, not more than 15 μ, and did not possess a flagellum. We have been unable to find any organism in the dry films made from this animal.

Inoculations were made intraperitoneally into healthy dogs from the heart-blood of a buffalo (5·0 c.cm.) and a wart hog (5·0 c.cm.) shot by Dr. Yale-Massey close to our camp at Broken Hill. The buffalo belonged to a herd known to frequent tsetse areas in the locality. In neither case did the dogs become infected.

VIII. SUPPLEMENTARY NOTE TO OUR 'REPORT ON TRYPANOSOMIASIS OF DOMESTIC STOCK IN NORTH-WESTERN RHODESIA'*

INFECTION BY *T. dimorphon*, pp. 104-112.

On our departure from Broken Hill all infected goats and sheep were left at the camp in charge of a native, but were kindly visited on one or two occasions by a European, who has informed us these animals all succumbed before the end of January, 1908.

Donkey, Case No. LV, page 108. This animal remained in splendid condition and indeed improved, and in March was sold at an enhanced price, despite the purchaser's knowledge of his history. He was alive and working well at the end of December, 1908, thirteen months after trypanosomes were seen in his blood. We have to thank the Administration for making arrangements for the regular inspection of this animal by the local Medical Officer.

The strain of *T. dimorphon*, derived from Case XXV, was taken away with us in guinea-pigs and rats, but owing to the shortage of these animals it was permitted to die out at Madona early in 1908.

INFECTION BY *T. vivax*, pp. 112-117.

We paid a hasty visit to Broken Hill in November, 1907, two months after our departure, and were then informed by the native in charge that sheep, Case XXXIX, had been one of several killed by a leopard the previous week. With the loss of this animal the strain disappeared.

Donkey, Case No. LVIII, page 114. This animal was re-purchased by his original owner on return from leave, and taken to Chinsali, where we again examined him in May and August, 1908, without finding any signs of trypanosomiasis.

MORPHOLOGY OF THE CATTLE TRYPANOSOMES, pp. 118-123.

In a later publication we have discussed the nomenclature of these trypanosomes, and more recently we have emphasised the view that the Broken Hill *T. dimorphon* is identical with the original of Dutton and Todd, which is distinct from that strain later employed both at

* *Annals Trop. Med. and Parasit.*, Vol. II, No. 2.